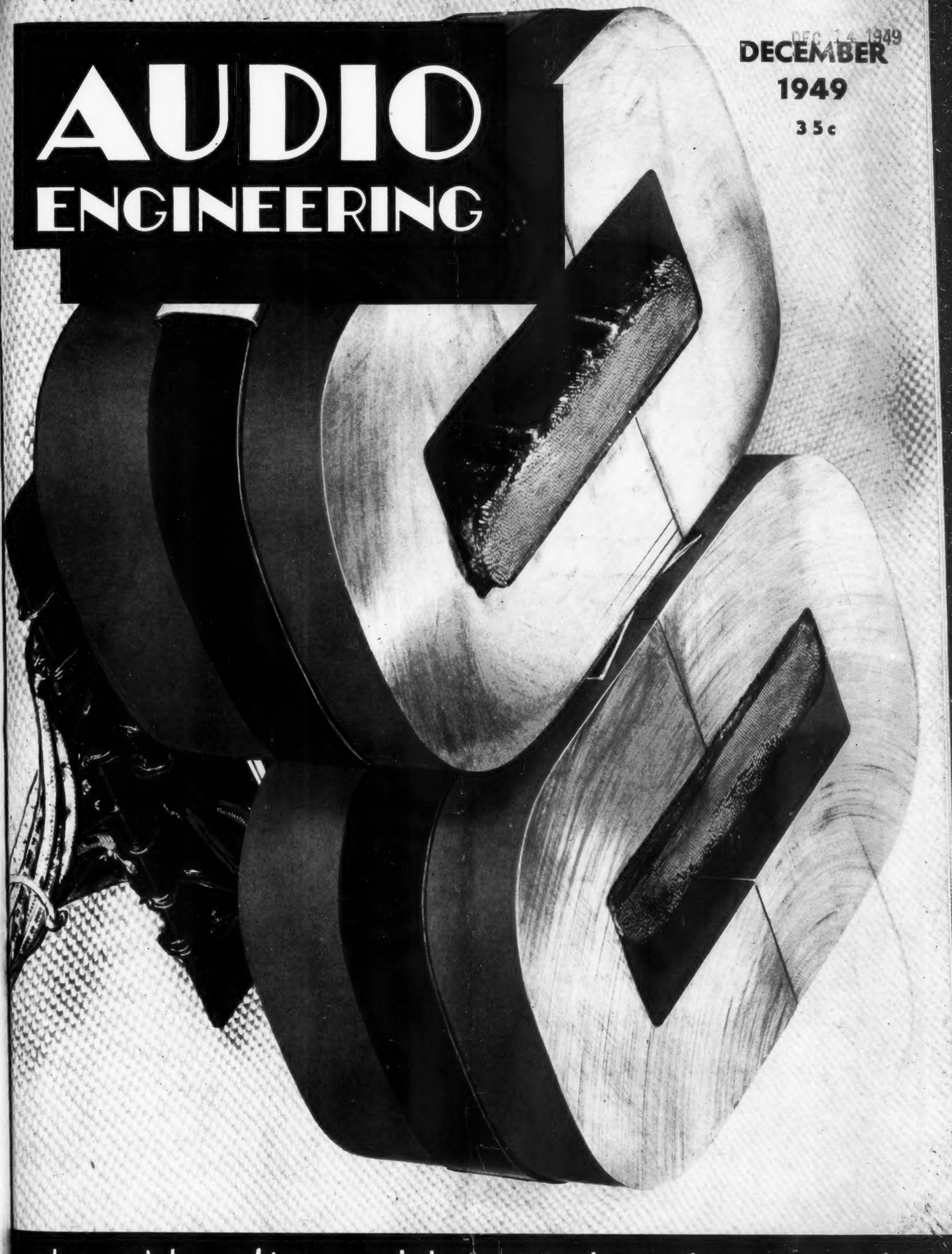
AUDIO ENGINEERING

DECEMBER

1949

35c



AUDIO ENGINEERING

Successor to RADIO
Established 1917

MEMBER AUDIT BUREAU OF CIRCULATIONS

CONTENTS

DECEMBER, 1949 Vol. 33, No. 12

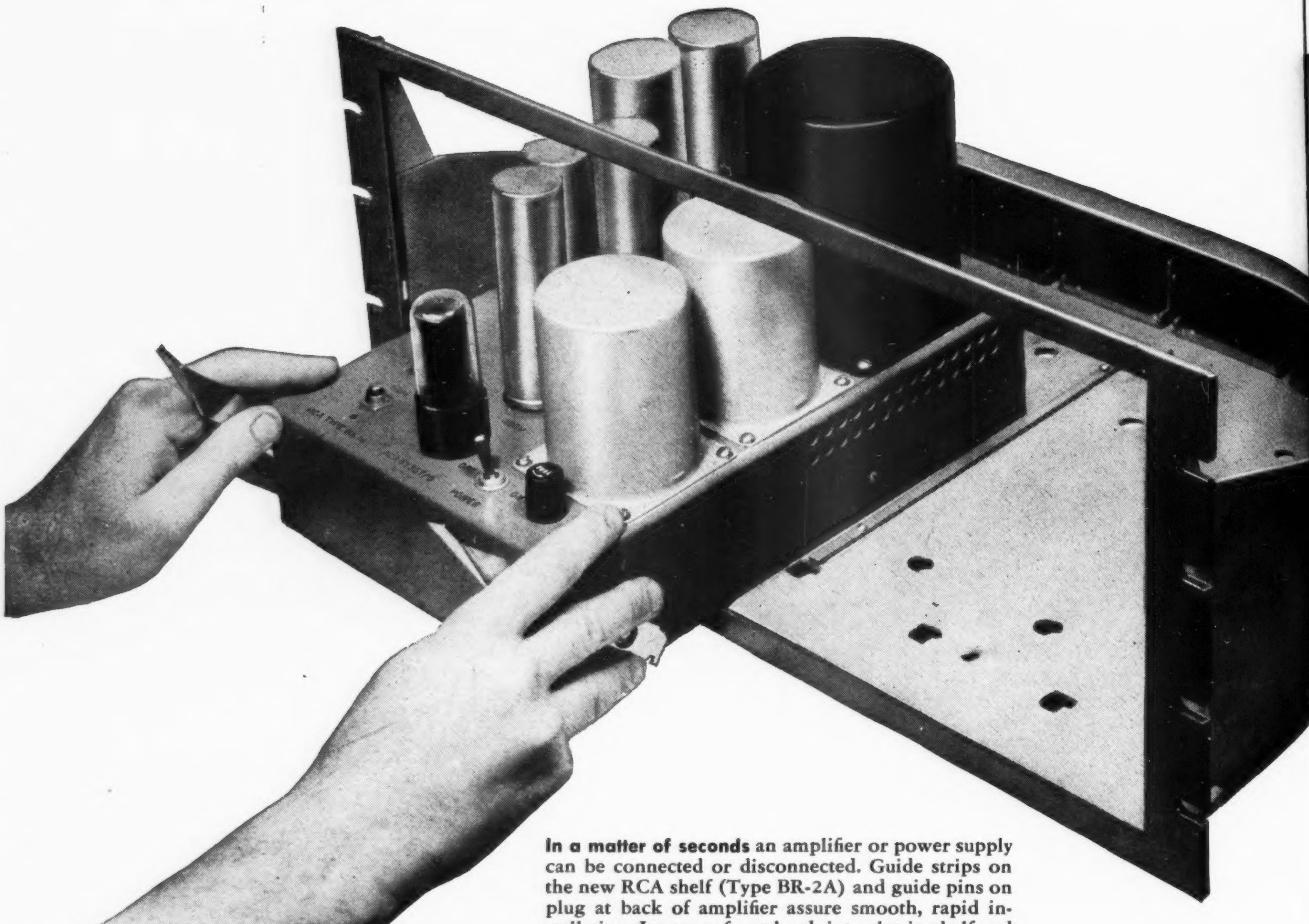
COVER

The cover picture is a cross section of the output transformer for the McIntosh 50-watt amplifier using a "take turn" primary which provides 100 percent coupling between the two halves of the primary. The unit utilizes four square inches of hypersil grain-oriented core material and a winding of special design permitting wide range 10 to 200,000 cycle transformation. The core weighs approximately 11 pounds. The terminal strip at the bottom includes connectors for the primary and secondary leads.

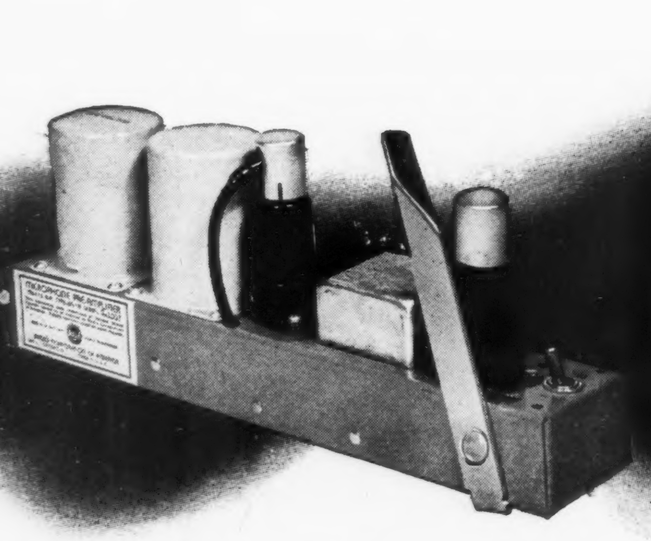
AUDIO ENGINEERING (title registered U. S. Pat. Off.) is published monthly at New York, N. Y., by Radio Magazines, Inc., D. S. Potts, President. Executive and Editorial Offices at 342 Madison Avenue, New York 17, N. Y. Subscription rates—United States, U. S. Possessions and Canada, $3.00 for 1 year, $5.00 for 2 years; elsewhere $4.00 per year. Single copies 35c. Printed in U. S. A.

Entered as Second Class Matter July 29, 1948 at the Post Office, New York, N. Y. under the Act of March 3, 1879.

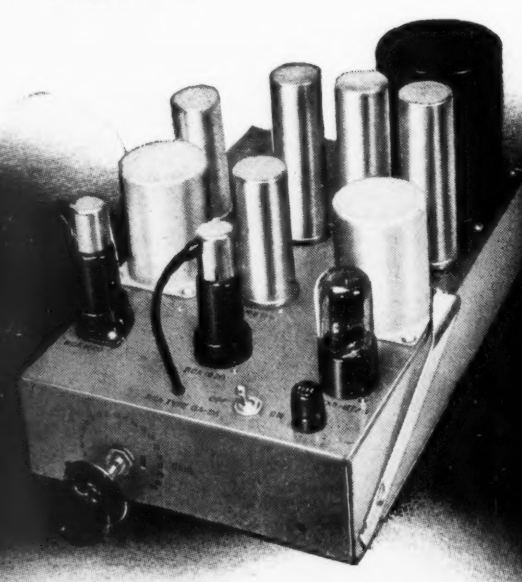
RCA "*PLUG-IN*" amplifiers fo



In a matter of seconds an amplifier or power supply can be connected or disconnected. Guide strips on the new RCA shelf (Type BR-2A) and guide pins on plug at back of amplifier assure smooth, rapid installation. Levers at front hook into slot in shelf and pull amplifier into place. Sockets on bracket at rear of shelf permit self alignment of receptacle with amplifier plug. (Shown is the BX-1B Power Supply Unit.)



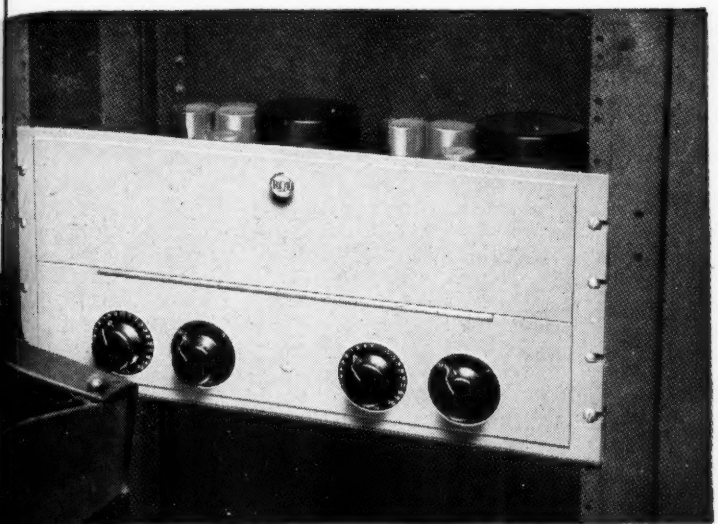
Two-stage Preamplifier (Type BA-1A)—ideal for use as a microphone preamplifier, turntable preamplifier, booster amplifier, or low-level isolation amplifier. *High gain:* 40 db. *High output:* +10 db. *Low noise level:* −80 db. *Low distortion:* 0.5% rms, 50 to 7500 cycles. *Isolation factor:* approx. 90 db; over 100 db with special Volume Control Kit. *Frequency response:* ±1 db, 30 to 15,000 cycles. *Small size:* six units will fit on a 36-B or new BR-2A shelf!



Booster Amplifier (Type BA-2C)—A two-stage unit having applications similar to those for the BA-1A; also valuable where a high-gain amplifier between announce microphone and limiting amplifier is required. *High gain:* 50 db. *Low noise level:* −68 db. *Low distortion:* 0.75% rms, 40 to 15,000 cycles. *Frequency response:* ±1.5 db, 30 to 15,000 cycles. *Compact:* two units can be mounted on one 36-B or BR-2A shelf. Features plug-in capacitors and built-in power supply.

fide
pro
cue
acc
2 w
for
Lov

for quick interchanges– *and easy maintenance*



The RCA Type BR-2A Shelf fits any standard rack; takes 8¾ inches of panel space. If desired, however, RCA Type 36-B panels and shelves now in use can be easily adapted for plug-in amplifier service.

All units available for immediate delivery

As easy to install or remove as an electronic tube! Pull a lever near the front of the amplifier and the plug on the rear of the unit is smoothly withdrawn from its socket—automatically disconnected from the supply voltage. No longer is it necessary to crawl around to the back of hard-to-get-at racks and unsolder or unscrew countless connections. System changes can be made quickly; minutes can be slashed from inspection, servicing, and testing time.

This new RCA line now includes the four amplifiers and one power-supply unit shown. Others will be added in the near future. New, carefully selected characteristics make these units ideal for a large number of studio jobs.

All units use the same standard plug. To assure maximum convenience, a new shelf (Type BR-2A) has been designed. With a few easy changes, however, the conventional RCA Type 36-B panel and shelf can be used, if desired. The necessary accessories are available for this purpose.

Here, we believe, is a real opportunity to modernize your amplifier system—a quick, convenient way to get better performance at low cost. Descriptive leaflets are yours for the asking. Write: Dept. 7L Audio Equipment Section, Radio Corporation of America, Camden, N. J.

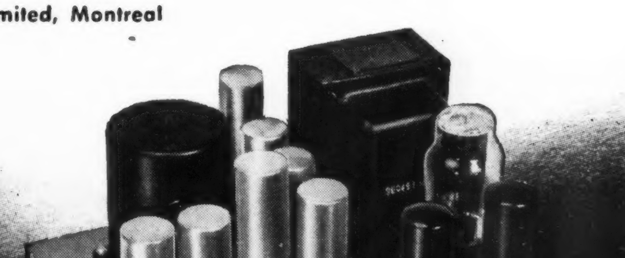
BROADCAST EQUIPMENT

RADIO CORPORATION of AMERICA

ENGINEERING PRODUCTS DEPARTMENT, CAMDEN, N.J.

In Canada: RCA VICTOR Company Limited, Montreal

New Program Amplifier (type BA-13). The most versatile high-fidelity amplifier ever designed for broadcasting. Ideal as a program or line amplifier, bridging amplifier, isolator amplifier, cueing or monitoring amplifier. Improved layout for greater accessibility; "plug-in" electrolytics for ease in servicing. *Output* 2 watts (approx.). *Higher gain,* 65 db for matching input; 28 db for bridging input. *Lower noise level,* –82 db (with max. gain). *Lower distortion,* less than 0.5 to 1% rms, depending on output level. *Frequency response,* ± 1 db, 30 to 15,000 cps.



Monitoring Amplifier (Type BA-14)—Designed for operation at microphone levels. High output of 12 watts is sufficient to drive several speakers or, in some applications, a recording head. Other uses include application as line amplifier for portable and mobile transmitters. *High gain:* 105 db. *Low noise level:* –20 db (with maximum gain); –40 db (with minimum gain). *Low distortion:* less than 3% at 12 watts. *Frequency response* ±2 db, 30 to 15,000 cycles.

EDITOR'S REPORT

THE AUDIO FAIR

ON THE 29TH OF OCTOBER, the first Audio Fair passed into history. For the first time, an entire convention and the displays of 56 exhibitors were devoted solely to audio, with a total registration of 3022. This is more than four times the membership of the sponsoring organization, the Audio Engineering Society.

For three days the sixth floor hall of Hotel New Yorker was crowded with interested visitors—both members and guests—and music in varying degrees of loudness filled the air. It was a first audio exhibit, with no traditions to uphold, no preconceived ideas which had to be followed, no experience to lean on. The entire Fair was designed to show audio equipment to advantage—in a setting where those who came to see could also hear. Everyone—exhibitor, visitor, and Society officer—was enthusiastic.

The technical sessions of the convention offered a long list of papers, and attendance at these meetings averaged around 250. The Society may justly be proud of its first effort and of the interest shown by those who came to hear and see.

Of greater importance, however, is the justification shown to those who have had faith in audio for these past years. AUDIO ENGINEERING is the result of this kind of faith, and while the overwhelmingly large attendance may have been a surprise to many, it was not to those of our readers who were able to be present. Audio *is* established as a separate science or art—or a combination of both—and is beyond doubt one of the most interesting to those who follow it. The Fair did much to help this general recognition of Audio, and we now look forward to a bigger and better Fair in 1950—the one exhibit designed expressly for the unique requirements of audio equipment.

COMING ATTRACTIONS

Scheduled for the January issue is the first part of H. W. Augustadt's paper "Longitudinal Noise in Audio Circuits," recently presented at the Convention of the Audio Engineering Society. This paper treats a subject which is important to broadcasters and others who use program loops, particularly when such loops are subjected to external fields. Little has been published on this subject heretofore, and the paper deserves a place in every broadcast station.

In reply to many inquiries about the miniature tweeter which was pictured with the Ampex article in the August isue, Walter T. Selsted has prepared a paper on this unique addition to a high-quality speaker system. It will also appear in the January issue, along with a new method of obtaining an *apparent* stereophonic sound source in reproduction of music, one which can enhance the overall effect even though it is not a true method of stereophonic reproduction. Perhaps this is one way the music lover can make sure of getting a lot of "presence" in the months after Christmas.

And, in the meantime——

The Editors and Staff of Audio Engineering wish you a very Merry Christmas and a Happy New Year.

— Letters —

The Other Side

Sir:

Can you truly call the magazine "Audio ENGINEERING" if you run a series of articles as proposed by M. H. Schwartz in the September issue? Perhaps the need for such articles carries with it a sting for those of us who profess to be Audio Engineers. Either there are not enough of us to support such a magazine as you have been producing, or we are somehow to blame for not producing articles which should be published.

May I call the attention of the truly serious minded audio hobbyists to the book by L. B. Arguimbeau titled "Vacuum Tube Circuits." The mathematics are not difficult in general, and in my opinion it is the best book ever published for the audio engineer.

Wm. P. West
3910 Vaux St.,
Philadelphia 29, Pa.

Logarithmic Meters

Sir:

In the September issue Mr. LeBel in his article "New Developments in Logarithmic Amplifiers" states "this construction (shaped pole pieces) has been used for indicating meters, but not for recording meters, due to practical difficulties."

In 1944 we used an Esterline-Angus recording milliammeter with shaped pole pieces to give a response linear with temperature in connection with a radiation pyrometer. Since the energy radiated is proportional to the fourth power of the absolute temperature, the profile of the pole pieces was cut to the second-power curve with corrections for the width of the moving coil. In this case the pole pieces were cut away instead of increasing the coil clearance as LeBel shows in his *Fig.* 2. To correct for sluggishness at the lower end of the scale, a magnetic shunt was placed across the pole pieces to reduce the peak field strength. To correct for the under-damping at the high end of the scale, a contoured aluminum vane was attached to the meter movement and fitted in the gaps of two fixed Alnico magnets. Three of these meters were modified at the time with much improved design in the subsequent modifications.

This work was done at the Research Laboratory Division of General Motors Corporation in connection with temperature measurements in an induction heating furnace.

W. James Trott,
Route 3, Box 472B
Orlando, Florida

Loudness Control

Sir:

In constructing the loudness control described in Mr. Turner's article in the October issue, several simplifications presented themselves. Being unable to locate the recommended pot, I used a 0.25-meg IRC audio-taper midget volume control. After removing the dust cover, four holes just large enough to pass a #22 wire were bored through the Bakelite at the proper points just inside the inner circumference of the resistance element. Small solder beads were put on the ends of four lengths of #22 wire and the wires pulled through the holes until the beads were flush with the resistance element. A force fit of the wires is easy to make in this way. Although friction contact is made with the resistance element, continued contact was insured by putting a small drop of #1200 Carbon-X at each junction.

A small four-terminal strip was soldered to the dust cover, and the wires terminated on the strip when the cover was replaced. Additional stability was obtained by putting a drop of Bakelite cement at each of the four points where the wires came through the unit on the panel side. An eight-terminal strip also soldered to the dust cover and extending back away from the control provided ample terminals for the associated resistors and capacitors.

C. E. Hablutzel,
717 Linden,
Shreveport, La.

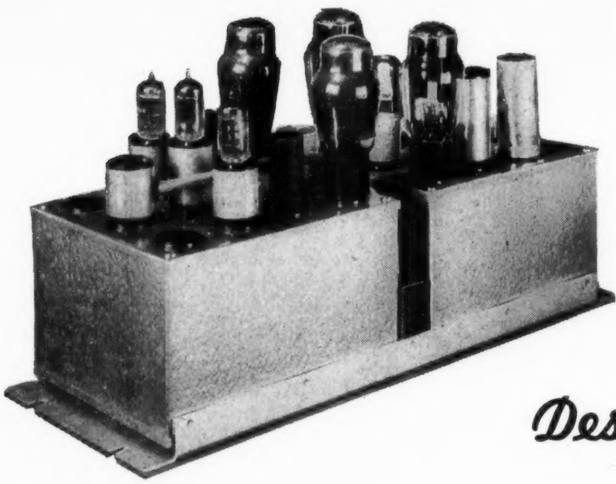
An English Booster

Sir:

I thought you might like to know how much your magazine is appreciated over here in England. As you may know, most of our magazines hardly touch recording.

Would it be possible at some time in the near future to include an article on the methods and equipment used by American recording companies? I realize that the number of English readers must be comparatively small, but I am sure our keenness makes up for it.

J. Curtis,
Tru-Sound Records,
41 Collingwood Road,
Northampton, England



The first major change in years in amplifier coupling circuit principles is discussed, together with details of the components employed.

FRANK H. McINTOSH*

and

GORDON J. GOW*

Description and Analysis of a New 50-Watt Amplifier Circuit

AUDIO AMPLIFIERS—being one of the oldest forms of equipment built using the three or more element tube—are now one of the most difficult devices to improve, and perhaps no other field of electronic endeavor has been given more time or has been studied by more people. One of the major reasons sound amplifiers are difficult to design is the requirement for very wide frequency range, highest to lowest running up to 20,000 to 1 in order to meet the ever-increasing demand for

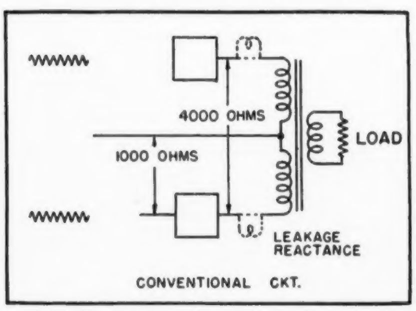


Fig. 1. Simplified output circuit of conventional push-pull amplifier.

more faithful reproduction of the audio range of from 18 to 20,000 cps. This wide range is probably the most rigid requirement for any electronic device regardless of its use. To satisfy the design requirements for an audio amplifier, several problems must be overcome. At the low end of the audio band the requirement for sufficient core material of proper magnetic properties must be weighed against core loss, weight, size, and expense. These quantities bear an inverse relationship to the total number of turns, but the total turns bear an inverse relationship to the leakage inductance and the effective shunt capacitance. At frequencies of 3,000 cps and higher the shunt capacitance across the primary circuit of output transformers becomes one of the major limiting factors, regardless of the mode of operation of the output stage. When the output stage is operated Class AB or Class B to improve the efficiency, then an additional problem growing out of the switching from one side of the circuit to the other in the output stage and thus producing a transient has been a barrier for over 20 years and has made practically useless such circuits except in applications where the harmonic content was not of great importance or where the range was limited over which such circuits are operated. This transient appears as

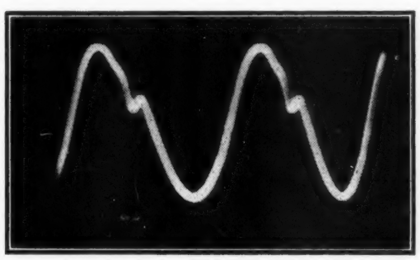


Fig. 2. Oscilloscope trace showing notches in output wave when operating between Class A and Class B.

a notch in the signal wave form and was first described in 1936[1] but for which no solution was suggested beyond that of reducing the leakage inductance of the output transformer or of biasing the amplifier stage back to Class A operation.

The basic circuit which we are about to describe grew out of an attempt to meet many considerations and requirements based upon tests and measurements made concerning the ability of the ear to detect distortion, the range and power of speech and musical instruments, the impulse characteristics of sound, the load impedance variations and effects of loudspeakers and other devices. A treatment of these basic requirements must be reserved for a later discussion.

Output Circuit

Figure 1 illustrates the output circuit of the conventional pushpull amplifier in simplified form. It will be seen that the plates are connected in the conventional way to the primaries of the output transformer and the resistor forming the load is shown connected to the secondary. The plate-to-plate impedance in this circuit is 4000 ohms. This is about right for a pair of 6L6's as used in the McIntosh 50W-1 amplifier. Attention is called to the 1000-ohm impedance which corresponds to the circuit from the plate to the center tap of the primary of this output transformer. These impedances should be born in mind as later reference will be made to them as part of

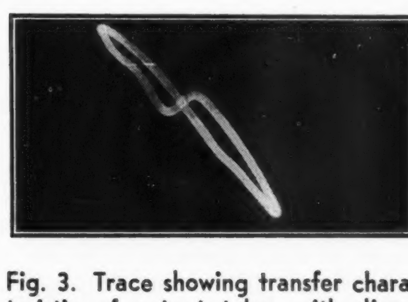


Fig. 3. Trace showing transfer characteristic of output tubes with discontinuity due to notch of Fig. 2.

the description of the new circuit. In the discussion to follow it is assumed that each of the tubes in the output circuit alternately cease to draw current during a portion of the audio

[1] A. P. Sah, Quasi-Transients in Class B Audio Frequency Push-Pull Amplifiers, *Proc. IRE*, Nov. 1936.

**McIntosh Engineering Laboratory, Inc., 910 King St., Silver Spring, Md.*

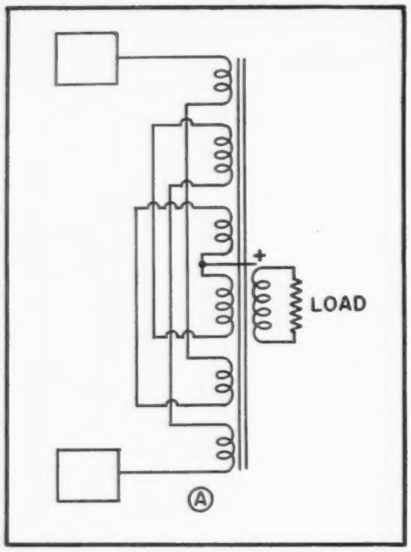


Fig 4. One method of minimizing leakage reactance by use of sectionalized primary winding.

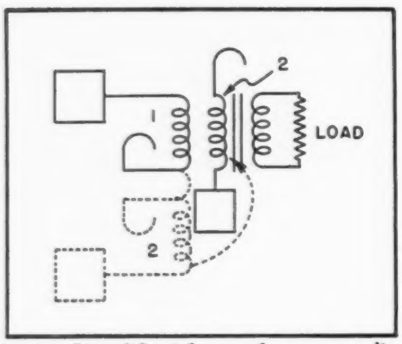


Fig. 5. Simplified form of new coupling arrangement for amplifier output stage.

cycle and, therefore, are operated somewhere between Class A and Class B.

Experience has shown that using the circuit of *Fig.* 1 and operating between Class A and Class B will result in a deformity, appearing as a "notch" as shown in *Fig.* 2 for all frequencies above approximately 2,000 to 3,000 cps. This waveform distortion measures 2 to 10 per cent or more depending upon the frequency and the leakage reactance existing between the two primary windings. This "notch" occurs because there is a residual leakage inductance in the plate circuit of each of the output tubes which becomes a source of voltage independent of that voltage driving the stage at the instance when one tube ceases to draw current and the other tube draws more current. This residual inductance or leakage reactance acts like an inductance through which the current has suddenly been cut off, and it generates a back e.m.f. which distorts the output wave. The value of this leakage reactance must be minutely small so that the distortion of the wave form at the highest frequency will not exceed 1 per cent. This effect has no panacea, so far as we know.

Negative feedback, the usual panacea, does not improve the situation, as might be expected, but rather tends to make it worse. To cancel the notch in the waveform a current flow would be required through the tube in the reverse direction to that which the electron flow permits, at the time the tube ceases to draw current during the normal cycle of operation. Another way to describe what happens in the circuit is to consider *Fig.* 3. Here is shown an oscillographic trace of the transfer characteristic of the output tubes. The presence of leakage reactance between the two primary windings causes a discontinuity to exist in this characteristic. This is the barrier which has been the source of frustration of many engineers for years past and is perhaps the major reason that high efficiency and low distortion could not be made compatible.

Reducing Leakage Reactance

There are a number of approaches aimed at reducing the leakage reactance but the penalty has been so great that the value of the increased coupling between primary windings has been offset sufficiently to make these approaches no solution at all, or of little value. *Figure 4* shows symbolically the sectionalizing of the two primary windings shown in *Fig.* 1. Here the primary is made up of many coils which are connected in such a fashion as to tend to make all the windings occupy the same space. This is an effective means of increasing the coupling between two coils and does increase the frequency at which the "notch" first appears. However, this approach has the disadvantage of increasing the shunting capacitance effects between the two plates of the circuit to such an extent that the high frequencies are by-passed. There doesn't seem to be any practical way to sectionalize and interleave these windings to eliminate the leakage reactance effect

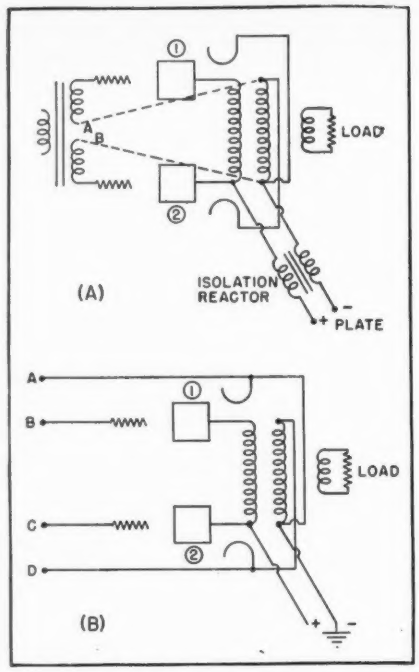


Fig. 6. Steps in development of coupling circuit.

and at the same time avoid the shunt capacitance effects. Another method which suggests itself as a result of the experience just described is to use a much larger core, permitting a reduction in the number of turns required in the windings of the primary circuit. This approach requires a very large core in the order of 125 pounds to effect a sufficient reduction in leakage reactance. This compares very unfavorably with the 11-pound core required in this new unity coupled output circuit for the same performance. It may be well to mention here also that the use of a large core has several other disadvantages among which is higher distortion, particularly at low output levels. This is due to the non-linear characteristics of the magnetic material and the relative-

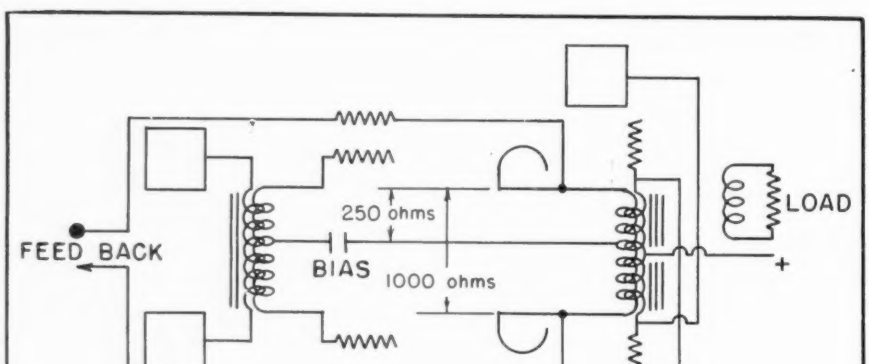


Fig. 7. Final basic arrangement employed to provide d.c. voltage for screen grid, but at the same a.c. potential as the corresponding cathode.

ly larger total loss in the larger core. It would be well to point out at this time that for 6L6 tubes operated in Class AB or Class B, the ratio of inductive reactance of the primary of the output transformer to the leakage reactance between the primaries must be 80,000 to one or greater to permit 1 per cent distortion at 20 kcs and full output to as low as 20 cps.

From the above discussion it seems impractical to reduce the leakage reactance sufficiently to permit high-efficiency operation and the only hope, therefore, is to go back to a conventional Class A arrangement where a discontinuity in the current drawn by each of the tubes does not occur over the operating cycle. The solution for high efficiency operation requires an unconventional circuit which will effectively eliminate the leakage reactance between the primary windings.

Figure 5 illustrates the approach made to circumvent the problems described above. The conventional output primary circuit is again shown with the primary marked *2* in dotted form. For simplicity the power supplies are eliminated and the midpoint of this primary is shown connected to the associated cathodes. The solid position of primary *2* is shown adjacent to primary *1* and this illustrates the first step in the development of the unity coupled amplifier. These two primaries are wound

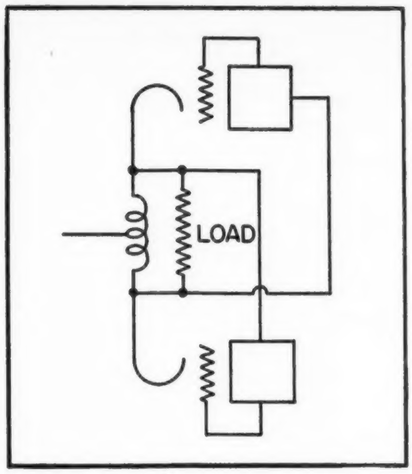


Fig. 8. Equivalent circuit simplified from Fig. 7.

together in a bifilar manner as if they were one winding and, therefore, there is between them both a capacitance coupling turn by turn, and a magnetic coupling due to the presence of the common core. Since the wires occupy practically the same space, the coupling is exceedingly high and measurements show that it is practicable to wind coils with a ratio of primary inductance to leakage reactance much better than 200,000 to 1. This, therefore, provides a way to eliminate the leakage reactance which in conventional transformers far exceeds the minimum ratio requirement of 80,000 to 1. We now, therefore, have a system which appears to have promise by reason of finding a way to eliminate the leakage reactance between the primary windings which in turn removes the barrier which has blocked for so many years the use of high-efficiency circuits in high quality audio amplifiers.

It is obvious that other variations of approach have been considered which accomplish the desired purpose to some extent at least, such as winding the two primaries on a common core not bifilarly and utilizing a suitable capacitance for couping the ends of these windings so as to maintain the two windings at proper and identical a.c. potentials. One advantage of the bifilar winding is, of course, a reduction of the number of components required, and it sidesteps some of the difficulties which grow out of the use of alternate approaches. It may also be obvious here that since the two primary windings are unity coupled there is no longer any need for sectionalizing the primary as is common in high quality transformers today. This results in an economy in manufacture.

Circuit Arrangement

To make *Fig.* 5 a practical circuit, the cathodes are connected to one coil and the plates to the other coil without changing their position in the circuit from an a.c. standpoint but permitting

[*Continued on page 35*]

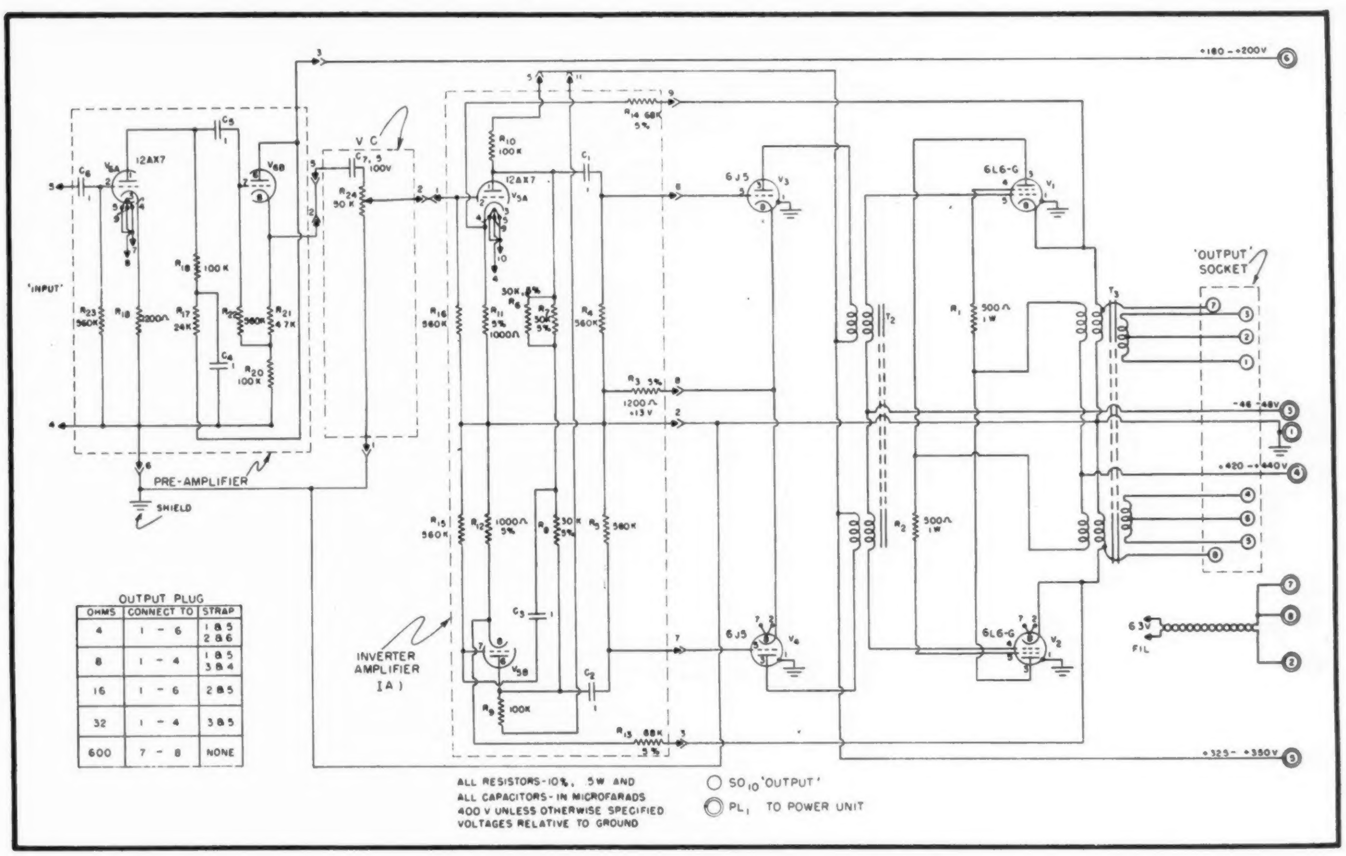


Fig. 9. Schematic of McIntosh 50W-1 amplifier.

Using the Reactance Chart *for Filter Design Problems*

H. B. DAVIS*

Calculations of components for various filter and equalizer circuits are simplified by graphical means.

The value of the reactance chart such as that shown in *Fig.* 1 is becoming more and more widely recognized as time goes on. Although it was originally indicated by Slonczewsky that the chart could be used for other purposes than reactance and resonant-frequency calculations, it is still largely used for that purpose. The other short-cuts offered by the chart have been largely neglected.

It has been known for some time that these charts could be used for certain filter calculations. It is the purpose of this article to show why this is true and how it may be done for several popular types of filters. Although the material may not be new to many readers, it is felt that there are others to whom the information may be of value.

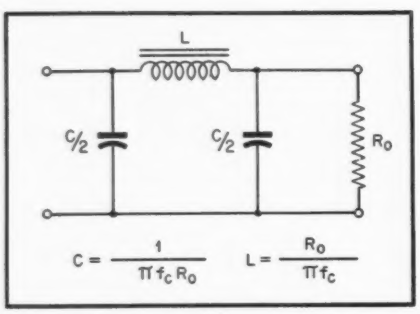


Fig. 2. Low-pass filter prototype, or constant-*k* section. R_o is the terminating resistance; f_c is cut-off frequency.

The chart is designed to solve equations of three parameters in which 2π enters as a factor. Specifically it solves such equations as

$$X_L = 2\pi fL \qquad (1)$$

$$X_C = \frac{1}{2\pi fC} \qquad (2)$$

$$f = \frac{1}{2\pi\sqrt{LC}} \qquad (3)$$

Solving for L and C in equations (*1*) and (*2*) gives

$$L = \frac{X_L}{2\pi f} \qquad (4)$$

$$C = \frac{1}{2\pi fX_c} \qquad (5)$$

The chart may be used to solve these or other three-parameter equations having 2π as a factor if the equation to be solved can be put into one of these or an equivalent form.

Inductive and capacitive reactance have the dimensions of resistance. Therefore, without changing the form of the equations of the ordinate of the chart equations, (*1*) and (*2*) may be written

$$R_1 = 2\pi fL \qquad (6)$$

$$R_2 = \frac{1}{2\pi fC} \qquad (7)$$

Solving equations (*6*) and (*7*) for L and C respectively gives

$$L = \frac{R_1}{2\pi f} = \frac{1}{2} \cdot \frac{R_1}{\pi f} \qquad (8)$$

$$C = \frac{1}{2\pi fR_2} = \frac{1}{2} \cdot \frac{1}{\pi fR_2} \qquad (9)$$

Equations (*8*) and (*9*) are seen to be very similar to the equations for the low-pass filter prototype shown in *Fig.* 2. The equations indicate, however, that the values given by the reactance chart for L and C will be equal to one half of the value calculated from the prototype equations if R_o is substituted for R_1 and R_2 and f_c is substituted for f.

For example, if it is desired to design a 10,000-ohm filter section with a cut-off frequency f_c of 1,000 cps, substituting these values in the equations of *Fig.* 2 give

$$L = \frac{10{,}000}{\pi \times 1000} = 3.18H, \text{ and}$$

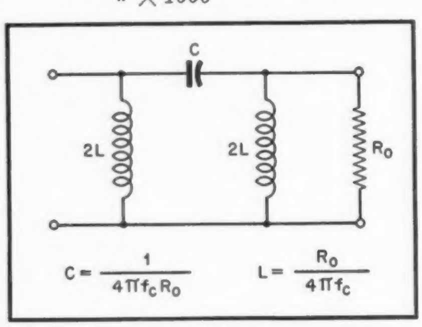


Fig. 3. High-pass filter prototype, or constant-*k* section.

$$C = \frac{1}{\pi \times 1000 \times 10{,}000} = 0.0318\ \mu f$$

Using the reactance chart and entering the chart at $R_o = 10{,}000\Omega$ at the intersection with the 1000 cps vertical, it

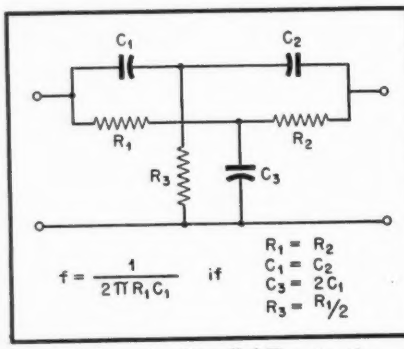
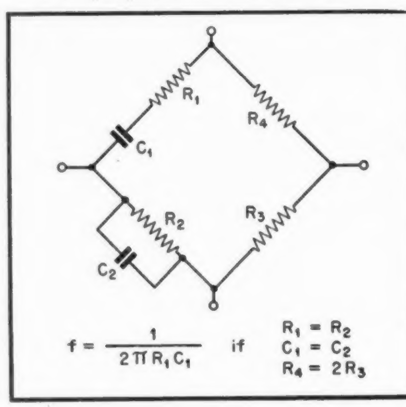


Fig. 4 (above). Parallel-T rejection or null network configuration.

Fig. 5. (below). Wien bridge circuit as employed in *RC* oscillators.



is found that L is given as 1.59 Henrys and C is 0.0159 μf. These values are exactly half of the values found from the equations.

In a similar manner, if f_c is substituted for f and R_o for X_L and X_c in equations (*4*) and (*5*), equations (*10*) and (*11*) result.

$$L = \frac{R_o}{2\pi f_c} \qquad (10)$$

$$C = \frac{1}{2\pi f_c R_o} \qquad (11)$$

These equations are seen to be simi-

*7721 Old Georgetown Rd., Bethesda 14, Md.

iar to the high-pass prototype equations shown in *Fig.* 3. Dividing both sides of equations (*10*) and (*11*) by two yields

$$\frac{L}{2} = \frac{R_o}{4\pi f_c}$$

$$\frac{C}{2} = \frac{1}{4\pi f_c R_o}$$

Solving these equations for L and C gives

$$L = 2 \times \frac{R_o}{4\pi f_c}$$

$$C = 2 \times \frac{1}{4\pi f_c R_o}$$

From these equations it is seen that the values of L and C obtained from the reactance chart will be exactly twice the value obtained from the high-pass filter prototype equations. That this is true may be verified by solving the equations for the filters and comparing the results with the values obtained from the chart.

If equation (*2*) is solved for f and [*Continued on page 40*]

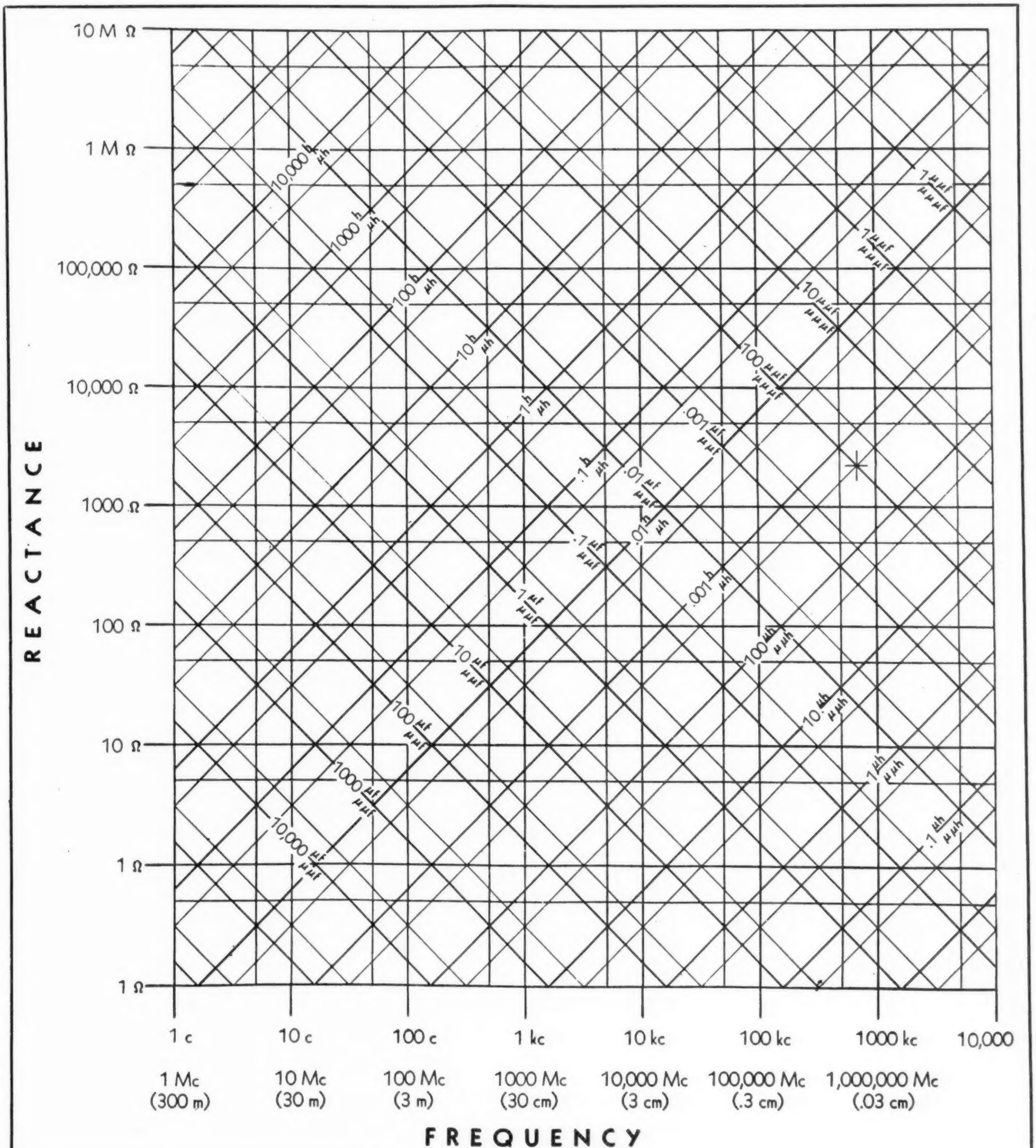


Fig. 1. The reactance chart, well known for its many applications in circuit calculations.

(Courtesy General Radio Company)

The Cathode Follower as Audio Power Amplifier

HOWARD T. STERLING*

As an output stage, the cathode follower is shown to be a feedback amplifier of special characteristics which can be duplicated in conventional amplifier designs.

In recent years there has been considerable interest in the use of the cathode follower for audio output applications. The proponents of the idea cite two principal advantages:

1. Lower distortion
2. Lower damping impedance
   - A. Providing better transient performance
   - B. Affording more independance of output transformer characteristics.

Assuming the validity of these proposed advantages, the principal disadvantages usually encountered are:

1. Extremely high driving voltages required
2. Relatively poor efficiency.

Drive Requirements

With regard to the poor efficiency encountered in the cathode follower output stage, let us consider the power relationships existing in such a stage. We must immediately realize that it is theoretically possible to get the same output voltage and current into a given value of load resistance as in the conventional amplifier, assuming sufficient driving voltage. In practice, however, the voltage output must necessarily be less than the driving voltage, and since the output current is limited by the tube, the power output will be proportional to the drive voltage available. If the output voltage is limited by the drive to some fraction of that which could be expected from a conventional amplifier, the power output will be limited proportionately.

This may be somewhat clearer if we compare the cathode follower with the conventional amplifier in a typical example. Suppose we use a pair of 2A3's. The tube manual gives the following data for push-pull, class AB_1, self-bias operation:

E_b	300 volts
E_g	−68 volts
R_L	5000 ohms
Power Output	10 watts

The plate-to-plate output voltage under these conditions may be found by:

$$E^2 = PR = 5000 \times 10$$
$$= 50{,}000$$
$$E = 217 \text{ volts rms}$$
$$= 317 \text{ volts peak}$$

or approximately 158 volts peak per tube. Now let us interpret this data in terms of cathode follower operation after the fashion of *Fig*. 1. Actually, in the case of the cathode follower, the peak E_o must exceed 158 volts by 68 volts (since there must be a signal voltage of this magnitude at the grid with respect to cathode) so that peak E_s must equal 226 volts per tube for equivalent power output.

A conventional driver using a 6J5 may deliver about 75 volts peak before running into serious distortion, or about ⅓ the voltage required for full output. Since we can get about the same signal output current through the tubes, the power output will be ⅓ of 10 watts or 3.3 watts. Then the signal E/I ratio will also be ⅓ and the cathode-to-cathode load should be ⅓ of 5,000 , or approximately 1670 ohms.

Drivers have been designed to operate from a 400-volt supply and deliver about 110 volts peak. Since this is half the drive required for full output, it should be possible to get an output power of 5 watts, represening about 50 per cent of the efficiency of the equivalent conventional amplifier.

With suitable tubes, and a high enough supply voltage on the driver, it is conceivable that one might realize the full theoretical output. If in the circuit of *Fig*. 1 a supply voltage of the order of 1200 were available, and tubes were used which would stand this supply voltage (the 2C53, or 807 with grid and screen tied together) adequate drive voltage could be achieved. There might be some question as to the economic practicability of such a solution.

Admittedly 2A3's are not the perfect tube for such an example, partly due to the fact that they are directly heated. There are, however, other considerations involved in the use of triode-connected pentodes, and 2A3's were chosen for the purpose of discussion in order to eliminate confusion.

If a beam tube is to be used as a cathode follower, with plate and screen tied to the supply (as shown in *Fig*. 2A), it is being operated as a triode and must be considered as such.

Triode Operation of Beam Tubes

In this connection, it should be pointed out that despite considerable

**Chief Engineer, Electronic Workshop, 351 Bleecker St., New York City*

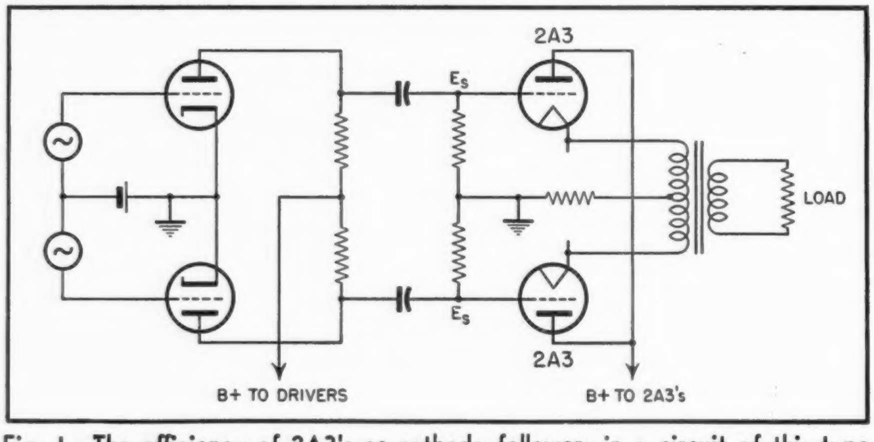


Fig. 1. The efficiency of 2A3's as cathode followers in a circuit of this type depends on the drive voltage available.

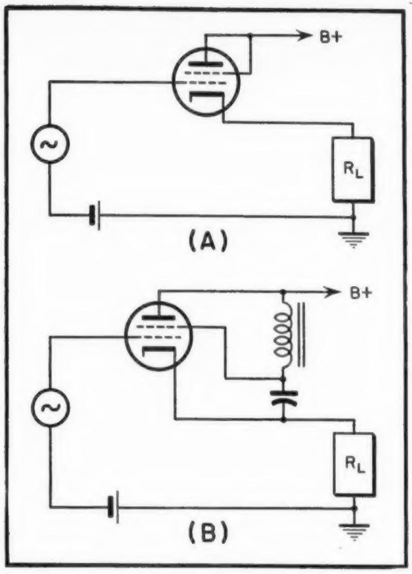


Fig. 2. (A) Triode-connected tetrode in cathode follower output circuit. (B) Tetrode connection for cathode follower.

experimental work which has been done in operating triode-connected 6L6's and 807's at voltages of the order of 400, this is operation in excess of ratings. The supply voltage should be limited to a potential which permits safe operation of the screen. It must be remembered that the screen grid accompanies the plate in its voltage excursions and reaches positive peaks equal to the sum of the supply voltage and the peak output voltage. These peaks should not be permitted to exceed published maximum screen voltage ratings.

A number of tube manufacturers consulted on this question say that while it is often possible to get away with operation in excess of rating and while many such amplifiers have been operating for years, there is no assurance of satisfactory tube life or dependability of characteristics.

If a triode-connected beam tube is operated as a cathode follower, it is still subject to triode characteristics, which are often less attractive than those for beam tubes. Only if the screen is decoupled from the plate supply and bypassed to the cathode (*Fig. 2B*) can the performance of the tube be determined on the basis of pentode amplifier operation.

There still remains the problem of supply voltage to the heaters. Since most indirectly heated tubes have a 100-volt heater cathode rating, and the signal at the cathode is likely to exceed this voltage, separate heater windings are necessary, and they should be well shielded electrostatically to avoid the introduction of hum into the load. Only the use of a tube like the 6AS7 with its 300-volt heater cathode rating would eliminate this necessity. Indeed, the low-voltage and high-current characteristics of the 6AS7 would make it most suitable for the purpose.

This matter of ratings need not preoccupy the designer of a single amplifier, unless he is concerned with considerations of good engineering practice, but it must be observed in the design of equipment for production.

Feedback Amplifier

To return, then, if we wish the normal advantages of cathode follower operation we must use extremely high drive voltages, or accept a loss in efficiency which will be proportional to the deficiency in drive.

At this point one might ask whether it is not possible to obtain these advantages of cathode follower operation without the attendant disadvantages. With this thought in mind, let us analyze the cathode follower, considering it as a feedback amplifier. The expressions for internal impedance and gain in a feedback amplifier are:

$$R' = \frac{R_P}{1 - A\beta}$$

$$A' = \frac{A}{1 - A\beta}$$

where R_P is the plate resistance of the stage without feedback and A is the open circuit gain of the stage without feedback (equal to μ for a single stage). β is equal to the fraction of output voltage fed back, and for inverse feedback will be negative. If we take the case of the cathode follower (*Fig.* 3A) and substitute in these equations, taking β equal to —1, then:

$$R' = \frac{R_P}{\mu + 1}$$

$$A' = \frac{\mu}{\mu + 1}$$

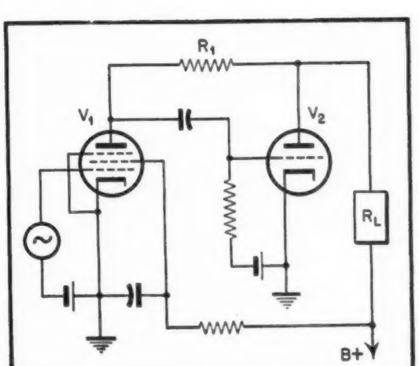


Fig. 4. Suggested drive circuit for Fig. 3B. V_1 is a pentode with $R_P >> R_L$.

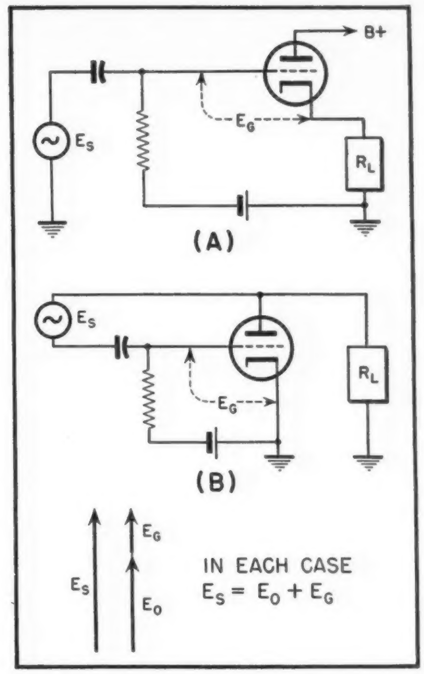


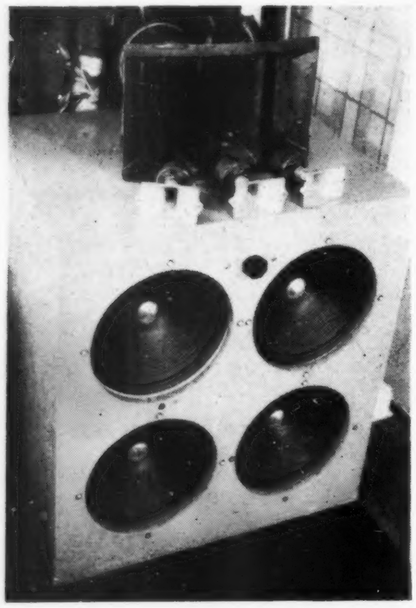
Fig. 3. (A) Conventional cathode follower. (B) Equivalent plate-coupled amplifier or "plate follower."

These will be recognized as the familiar equations for the internal impedance and gain of a cathode follower. Let us now take the case of the conventional feedback amplifier with β still equal to -1. If we then solve for the gain and internal impedance of this circuit we get the same results as for the cathode follower. This is of some interest insofar as it shows the virtue of the cathode follower to lie not in a special circuit configuration, but rather in the fact that it has such a large amount of direct-coupled inverse feedback. Now, comparing the circuits of *Figs.* 3A and 3B, we see that in the cathode follower the feedback voltage appears in the cathode return to ground, permitting us to use a ground reference for our input signal voltage and hence conventional coupling of drive to the stage. In the conventional amplifier, however, the input voltage is referred to the plate, making input coupling rather difficult. A possible solution is indicated in *Fig.* 4, where a pentode with R_P much greater than R_1 is used as driver. In any case E_s must be greater than E_o by a voltage equal to E_g.

Reference to the feedback equations will show that if A is constant then R' will be constant, so that if A is increased β may be decreased proportionately; R' will remain constant and A' will increase, and the required drive will then be reduced by the factor A'.

We can achieve this effective increase

[*Continued on page 28*]



Below 50 Cycles

SAUL J. WHITE*

In which the author relates some experiences with low frequencies while working toward their more realistic reproduction.

Most high-quality reproducing systems terminate their *acoustic* linearity above 50 cps. Even with bass compensation and a goliath speaker-enclosure, the possibility of maintaining acoustic linearity below 50 cps is almost non-existent. While some auditory sensation can be had through exceptional equipment, the final level is so far below the mid-frequency level that ordinary bass boost cannot restore to the listener the low frequencies as they existed at the microphone position. This is because:

1. Microphone sensitivity falls off rapidly below 50 cps.
2. Losses at the low end in the modulating equipment of the broadcasting station. FCC standards require ±2 db linearity to only 100 cps.
3. Improper compensation on recording or playback equipment or failure to adhere to NAB recording standards.
4. Severe cutoff in the loudspeaker. A speaker with its low-frequency peak at 65 cps (an excellent speaker at that) may be down as much as 30 db in sensitivity at 45 cps.
5. The poor sensitivity of the human ear to low frequencies at reduced volume levels. At normal room volume the loudness sensation of the ear may be down 20 db from its mid-frequency sensation. It will require a mere 100 times more watts compensation to restore physiological linearity. This factor will cause a quality audio system to appear deficient in lows.

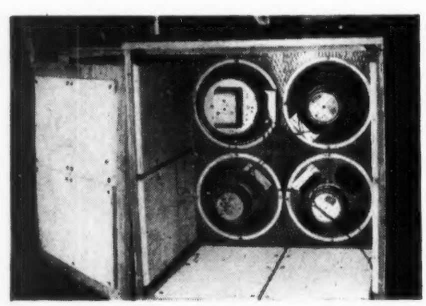
Starting with the objective of bass compensation below 100 cps, the author wound up with a low-frequency booster system with a gain of 50 db between 20 and 100 cps. This bass system is fed in cascade from the output of a conventional wide-range amplifier, which drives a woofer-tweeter system as shown in *Fig.* 1. The special bass amplifier drives a third speaker of special design which will be described later. Reproduction is thus obtained through a three-way system. Because of the excessive low-frequency gain and power output, many unexpected results followed. With reproduction capabilities down to perhaps 15 cps, observations were made of effects which contributed to greater fidelity and also served to measure the quality of broadcast equipment and technique. Certainly, sounds were reproduced never before heard over an audio system, and never intended by the broadcast stations to ever be heard. On the other hand, much flesh-and-blood program material almost lost by the transmitting equipment is restored.

The term "conventional system" when used in this article will refer to a woofer-tweeter system driven by an amplifier which is flat between 40 and 10,000 cps as measured on a resistor load. Though better than most single-speaker systems, this type of dual reproduction as yet does not give full and complete low-frequency accuracy to the original sounds. It is to this type of two-way speaker that the author has added a third speaker handling only low frequencies. (The original woofer speaker is here considered as a mid-frequency reproducer.) By cutting off the special bass system and listening only to the conventional system, an instantaneous comparison of the two types of reproduction was had. This, then, is a qualitative report of what may be heard from FM radio reception when bass compensation is lifted to ear linearity and far beyond . . .upward.

Live Programs

Live programs with speech origin develop a chestiness, somewhat pleasant if the bass boost is held within moderation. If exaggerated, huffs and puffs of breath become present. Words containing "aw" sounds as in *law* or *brawn* are grotesquely deformed. Words having deep long syllables, such as *war*, *swallow*, *smoke* and *proof* are similarly distorted. Some words, with excessive boost, will start with an explosive sound, especially those starting with "p" or "b." Even the breathing of a speaker can be made audible apart from the characteristic high-frequency hiss at the tweeters. A nervous person will reveal his condition by the rapidity of his breathing, adding a realism that is not felt over the conventional reproducing system. These vocal changes are not caused by the frequency content in speech, because the deepest voice is well above the operating range of this bass system. They are the result of pressure effects caused by pulses of breath and by the opening and closing of the lips known as labial characteristics.

The reproduction of live radio music with boost below 50 cps reveals the existence of much worthy material inadequately handled by the broadcasting stations. Of all live music, symphonic programs appear to be the most ill-handled, some instruments and notes not appearing at all when the special bass system is cut off to leave only the conventional woofer-tweeter functioning. Of course, if the bass boost is carried too far, bass drums, tympani, viola, contra bassoon and so on, become an overwhelming force, and the grill cloth in front of the bass speaker will flap like a sail in the breeze. However, the general character of the reproduction is never thick or muddy, as is the case with bass compensation systems that take hold at 200 or 300 cycles. Because of the extremely low frequencies at which this system functions, when judiciously handled, there is no



Rear view of bass speaker system described in text. Four 12-inch cones of similar efficiency and varying resonant frequencies are used.

*82 Elm Street, New Rochelle, N. Y.

alteration in the program bulk. This is because the time-frequency distribution of the added low frequencies is exceedingly small.

At no time is the tone boomy. When listening exclusively to the special bass speaker (pads in each speaker line permit individual attenuation), there is no recognizable melody. One hears only the true low-frequency beats. The release of a low-frequency pulse, occurring only occasionally as it does in some types of musical numbers, makes one immediately sense the improvement. Where the original conventional "flat" reproduction appeared satisfactory in handling bass, as in the percussion accompaniment of a swing number, the addition of boost brings a proud awareness to the improved quality. Furthermore, this type of boost will bring up that occasional extremely low note, below 50 cps, which otherwise could not be present. Unlike high-frequency boost with its likelihood of an increase in noise background, this bass compensation does not add any particular background or feeling of its existence while idling. However, its presence is felt with a start whenever switching of microphones or lines takes place at the station.

Compensation can be lifted to a degree where the hum level of the broadcasting station is audible. Remote pickup equipment of practically all stations is characterized by considerable 60-cps stray hum. It is possible to hear the switching of remote lines by the changes in hum levels. Even with a small amount of boost, it is possible to follow the monitoring procedure between programs. The handling of a microphone stand by a performer or announcer will easily come through. There are many unaccountable thumps tending to rupture the cone. Instrumentalists, especially guitarists, who keep time with their feet, send an unexpected rhythm along with their melody. Unfortunately it is neither precise nor clean. When first heard it was difficult to identify, sounding rough and variable in intensity. The character of certain sound effects is changed. The simulated closing of a door may sound as if the entire ceiling had fallen onto the living room floor. Pedal "thumping" never encountered on any other reproducing system can be heard on live piano numbers. Violent hand clapping carries with it a faint roar as if the mike were rocking.

Transcriptions

Programs originating with records or transcriptions need less bass compensation than live programs, although of course, they do not possess the realism of the latter. Turntable rumble can be readily turned up, and from what has been revealed, much equipment in the New York area is due for overhaul. When listening over the conventional system, bass characteristics will appear more or less uniform between various recorded numbers or between different stations. In other words, most recordings seem to possess more or less similar bass feeling, such as it is. But when the special low boost is advanced, a considerable variation in bass content is encountered. This may vary between successive dance numbers from a given station. This is probably due to differences in bass compensation of different transcriptions, and in the region below 100 cps may vary between barely audible to over-pronounced. This difference in transmitted bass level is hardly detectable over the conventional reproducer, yet these differences widen when the low frequency system is included. This wide gap in low frequencies also appears in live programs, but to a smaller extent.

This may be accounted for by (1) different microphones or positioning even in adjoining studios; (2) deliberate bass attenuation because of preference by conductor, producer or engineer; (3) poor low-frequency response of the telephone lines (even Class A) when pickup is remote or out of town; (4) inadequate low-frequency acoustic output in the station monitoring reproducer which fails to show up these variations, the unbalance between programs therefore being inadvertant.

Sometimes with low frequencies adjusted for desirable response on a certain program, the following program from the same station will have so much more bass as to throw the entire system into mechanical feedback or to develop hangover effects.

Low-Frequency Booster Amplifier

The low-frequency booster amplifier shown in elemental form in *Fig.* 1 consists of what was originally a conventional three-stage amplifier modified to reproduce only from 100 cps down. Its frequency vs gain characteristic is

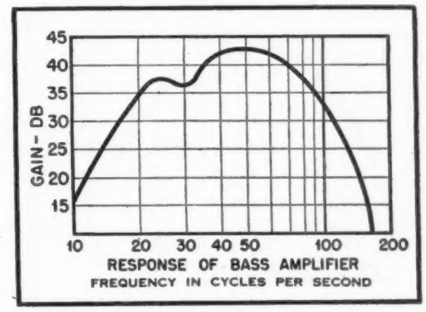


Fig. 2. Bass system amplifier of Fig. 1 provides large boost at frequencies where normal speaker response falls off.

shown on *Fig.* 2. It is a capacitance resistance coupled unit with push-pull parallel 6L6's in the output stage and having a power output of approximately 35 watts at 50 cps. Shunt capacitors with values to commence a 6 db loss at 100 cps were wired across each stage grid resistor. Coupling capacitor values of 0.1 μf are adequate where the plate-load resistors are not under 50,000 ohms. No trouble was experienced with blocking effects at high signal voltages. A triple-shielded (magnetically) input transformer is used to couple the driver to the input stage grid. Since this is a bridging arrangement, it has a pri-

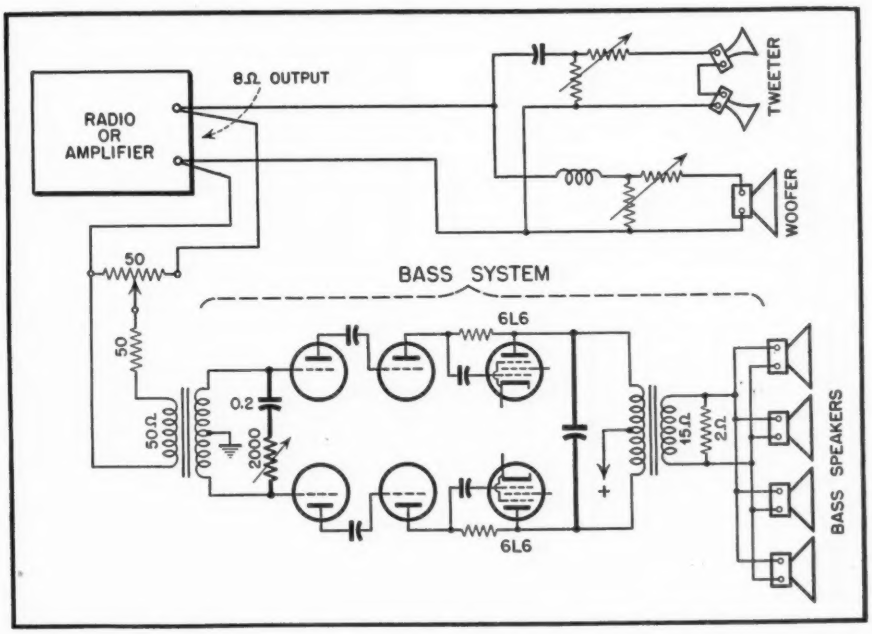


Fig. 1. Block diagram of multiple amplifier-multiple speaker arrangement used to enhance low-frequency output.

mary impedance of 50 ohms. The secondary is shunted with a 0.2 mfd capacitor and a series adjustable resistor. This forms a broadly tuned circuit at 40 cps. In operation the resistor may be adjusted to suit the character of the response sought. The output transformer primary is shunted with a capacitor to resonate at about 25 cps. The humps due to resonance are not sharp due to the low efficiency of the transformers at these frequencies. The two tuned circuits function broadly over a frequency area where the loudspeaker output would ordinarily disappear. However, this method of increasing low-frequency gain must be approached with caution since the results will vary with transformer Q. An excessive peak or trace of circuit resonance will give bad hangovers and disguise the fidelity of the original source. Needless to say, both the main amplifier and the bass amplifier must have lower-than-average hum level, or the performance will be unsatisfactory. Low line hum can be achieved by observing good design and construction technic, such as thorough shielding of all low-level wiring and components; direct current for heaters of the voltage amplifier stages, with all heater voltages about 10 to 15 per cent below nominal values; balanced push-pull tubes; well-filtered power supply with wide separation of input transformers from the power supply, large values of decoupling capacitors; and care in avoiding ground loops which pick up potential differences in the chassis and grounding leads.

The nominal 15-ohm output of the amplifier is shunted with a 2-ohm resistor for the purpose of damping the output, although this is attained at the expense of useful power. This achieves stiffening of the loudspeaker diaphragms at resonant frequency by electrical means. This system will be called upon to handle severe transients of high intensity and must do so without damaging the speaker. This is a stiffness controlled system, both electrically and acoustically, and while such systems are inherently insensitive at low frequencies, in this case they are driven into the speaker by brute force.

The Bass Speaker

The low-frequency loudspeaker is composed of four 12-inch cones mounted as close together as possible in an enclosure of approximately six cubic feet. No reflex ports are used, the objective being to stiffen the cones acoustically by a not-too-large airtight enclosure. The four cones tend to act as a single diaphragm of large diameter, but is should not be assumed that they will perform, in a practical sense, as a single cone of four times the area, i. e., 24-inch diameter. During early experiments, excellent results were obtained with a single 12-inch speaker in a cabinet measuring 20 x 20 x 20 inches. However, it and a replacement were shortly ruptured by these experiments. Nevertheless, models of single 12-inch speakers with proportionately smaller amplifiers give impressive results when held to room loudness levels. A two-speaker system would probably be adequate for most disciplined experimenters interested merely in high-quality musical reproduction.

The effort behind this speaker design is to reduce the resonance peak of the cone and to achieve a slow roll-off in sensitivity. A loosely loaded cone, that is, one in an excessively large cabinet, will have the lowest resonant frequency, but this will usually be in the form of a distinct peak and a steep roll-off below this peak, making smooth equalization difficult. In large cabinets at frequencies above resonance, the diaphragm is mass-controlled, and it is a characteristic of mass-controlled transducers that output falls sharply below resonance. A small enclosure adds stiffness, raising resonance and reducing low-frequency efficiency, as shown in *Fig.* 3. While the smaller enclosure will raise the resonant frequency of the speaker, seemingly giving it less bass, it is a preferable practice, since the peak is shifted to a higher point by the increased stiffening factor of the smaller rear volume and broadened by the change of mass-to-stiffness ratio. It was reasoned that amplifier power today is a cheap commodity, whereas high-efficiency, low frequency cone speakers, massive enclosures and horns are expensive. This system will surely appeal to those who wish greater bass output without placing a monstrosity in their home.

In this bass system it is important to suppress the amplitude of the speaker resonant peak, for unless this is done effectively, the whole reproducing system will develop acoustic feedback before adequate compensation is obtained. This develops because the mid-frequency speaker acts as an input transducer or microphone across the bass amplifier, and by virtue of the gain existing between the mid-frequency speaker and the bass speaker, acoustic feedback will set in. To some extent, this was overcome by attenuating the low end of the conventional amplifier and the high end of the bass amplifier so as to form an amplification crossover with a 10 db dip at the resonant frequency of the bass cones. It is clear also that it is impractical to place the two speaker groups too close together. If bass gain is carried too far, mechanical feedback may develop due to the microphonic sensitivity of the tubes and the physical coupling through the floor under low frequency stimuli, even with the speaker unit located at the opposite end of the room from the amplifier or tuner. This regeneration occurs whenever the gain of the mechanically vibrating tube-to-speaker circuit is greater than the transmission loss through the coupling medium, i. e., floor, chassis, tube elements, and so on. This regeneration is preceded by severe hangover, flutter and instability typical of all positive feedback arrangments.

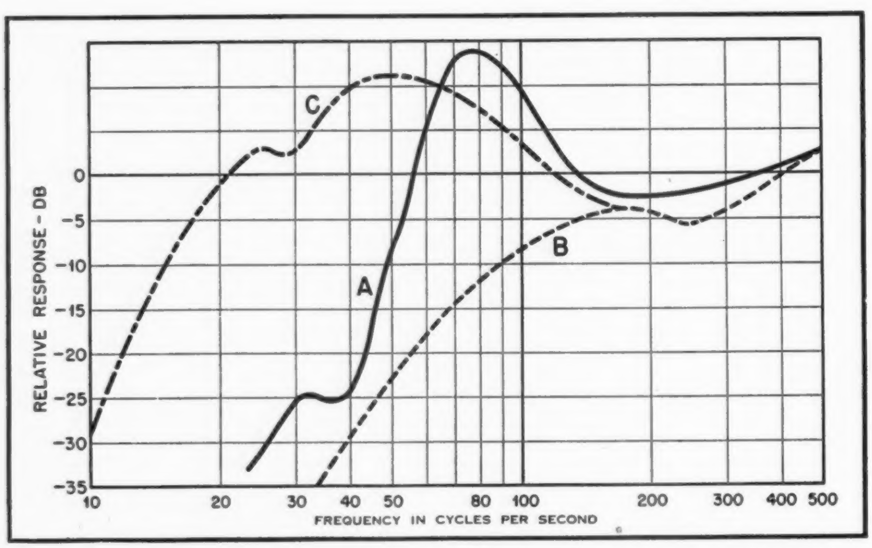


Fig. 3. Curves showing effect of adding low-frequency booster and speakers to normal system. (A) shows typical response of a so-called woofer in an enclosure of ample volume. (B) represents the same speaker enclosed in a small airtight cabinet. (C) represents speaker (B) with bass compensation added.

[*Cont. on page 31*]

AUDIO engineering society

Containing the Activities and Papers of the Society, and published monthly as a part of AUDIO ENGINEERING Magazine

Audio Engineering Society, Box F, Oceanside, N. Y.

OFFICERS

Theodore Lindenberg, President

J. D. Colvin............Executive Vice-Pres. John G. Frayne........Western Vice-Pres.
Norman C. Pickering............Secretary Ralph A. Schlegel....................Treasurer

Report on the Convention and The Audio Fair

The Audio Fair and first annual convention of the Society was a pronounced success in all respects. 1463 persons registered on the opening day while registration on the second day was 895, and on the third day was 664. With the repeats on the second and third days, it appeared that the attendance approached 1500 for each of the three days. The number of exhibitors totaled 56, and the entire sixth floor at the Hotel New Yorker was devoted to exhibits. The technical sessions were held in the second floor ballrooms of the hotel, and attendance at these ranged betwen 200 and 400.

The meetings on the first day began with a business meeting at which various reports were read by the secretary, treasurer and elections committee. The new officers announced were: president, Theodore Lindenberg, Fairchild Recording Equipment Company; executive vice president, J. D. Colvin, American Broadcasting Company; secretary, Norman C. Pickering, Pickering and Company, Inc.; treasurer, Ralph Schlegel, WOR Recording Studios. The Western vice president for the new year is John D. Frayne. Newly elected to the board of governors were C. A. Rackey, National Broadcasting Company; C. J. LeBel, Audio Instrument Company; and F. Sumner Hall, Audio Equipment Sales.

The activities of the banquet highlighted the three-day session. On Friday night, after short remarks by the officers, Chairman W. L. Black of the awards committee announced the selection of Dr. Harry F. Olson of RCA Laboratories as the recipient of the newly established John H. Potts Memorial Award for "outstanding achievement in the field of audio engineering." The society has the privilege of selecting each year the person who is to receive the medal, which was named for the late editor of AUDIO ENGINEERING Magazine.

Dr. Olson, a leading authority on acoustics, was a pioneer in the research and development of directional microphones, including the velocity type. Directional microphones are now almost universally employed in radio, sound motion pictures, and television. Loudspeakers developed by Dr. Olson range in size from the smallest to the largest, and he developed the first successful electronic phonograph pickup. He is a fellow of The Institute of Radio Engineers and of the Acoustical Society of America, and a member of Tau Beta Pi, Sigma Xi, and the American Physical Society.

C. J. LeBel was presented with the Society

The John H. Potts Memorial Award

Award for his contributions to the Audio Engineering Society, and honorary memberships were bestowed on Harvey Fletcher of Bell Telephone Laboratories, Vern O. Knudson of University of California at Los Angeles, and Frederick V. Hunt of the Cruft Laboratory at Harvard University.

The banquet concluded with an interesting demonstration of eleven high-quality loudspeakers in an A-B test. The audience was provided with rating cards, and the speakers were identified by letters only. The listeners individually rated each speaker on the basis of five types of program material, which included symphony, piano, and dialogue. No formal count was taken of the result. This portion of the entertainment was under the chairmanship of L. B. Keim, consulting radio physicist.

So successful was this three-day meeting that plans are already under way for a similar and possibly enlarged conference to take place at about the same time in 1950. Details will be announced in later months in this space.

RCA Institute Chapter Elects

The student chapter at RCA Institutes, in New York, announces the election of officers for the coming six months, with Lucien W. Marek being chosen as Chairman; Paul Bezold, vice chairman; Hagop T. Hatzakortzian, secretary; and Harry Weiss, treasurer. Committee chairmen appointed were: Cedric F. Lee, constitution; Frank Staffa, program; Lyle B. Dahms, publicity; Max B. Marek, membership.

The chapter is furthering its work by having regular meetings with prominent speakers, and by having close ties with the parent organization. Members are urged to work on projects and to write papers on them to gain experience in the presentation of such work.

Los Angeles Chapter Organizes

On the evening of Tuesday, October 13, sixty-one engineers gathered at Los Angeles to organize the local chapter of the Society. Dr. John Frayne, now Western Vice President, acted as parliamentarian to start the operation, ably prompted by Robert J. Callen. John K. Hilliard was elected Chairman of the local chapter, with Harry Bryant and Arthur Partridge being chosen as secretary and treasurer respectively.

Committee chairmen appointed were: R. J. Callen, program; Richard Burgess, arrangements; and Miss Louise De Nio, membership. The members selected the first Tuesday of the month for regular meetings, with Dec. 6 as the starting date.

Employment Register

Positions open and available personnel may be listed here at no charge to industry, or to members of the Society. For insertion in this column, brief announcements should be in the hands of the AES Editor before the tenth of the month preceding the date of issue. Address replies to AES Editor, Audio Engineering, 342 Madison Ave., New York 17, N. Y.

- **Communications Engineer** (MIT) 22, single, with good theoretical background and some experience; interested in research, development, or teaching in audio, acoustics, electric circuits, and vacuum-tube circuits. Box 111.
- **Audio Engineer:** Three years experience in magnetic tape development including pigment research, coating formulation, coating techniques, pilot plant operation, manufacturing control equipment and techniques. Broad background in all phases of film and disc recording. Box 112.
- **Graduate Student** of radio and television desires Junior Engineering position in audio or recording industry. Age 23, married, child. Willing to travel occasionally. Prefer midwest or south. Box 113.
- **Recording Engineer.** Experienced mixer; superior knowledge of classical music. Knows motion picture and radio mixing techniques. 30, married, presently employed. Graduate of Hollywood Sound Institute. Box 121.
- **Audio Engineer.** Graduate Hollywood Sound Institute, 25, married. Now attending television production school. Desire position with broadcast or recording studio, evenings. N.Y.C. Free to travel after January, 1950. Box 122.

AUDIANA

C. G. McPROUD

Recording Characteristics—1

A discussion of the various characteristics employed in making phonograph records, together with the reasons for their use.

THAT THE ULTIMATE in disc recording is to make the reproduced signal as near as possible to the original seems to go without further elaboration. This applies, of course, to any recording, but this discussion is solely about disc recording systems. To achieve faithful reproduction, therefore, it would seem that if all the components were made as perfect as it is possible to make them, it would suffice to record the signal and play it back with completely *flat* equipment. However, due to a number of limitations, this is not feasible, and the curve employed in recording is definitely not flat; consequently the curves employed in reproduction must deviate from uniformity. It is the purpose of this discussion to elaborate on the reasons for deviation in both the recording and the reproducing operations.

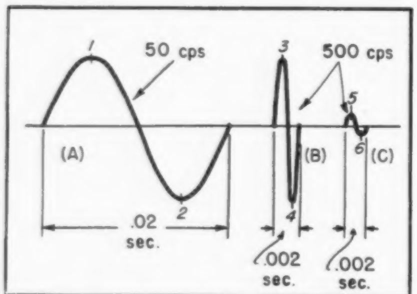


Fig. 1. Comparison between sine-wave signal plotted for 50 and 500 cps: at same amplitude, (A) and (B); and at same velocity, (A) and (C).

The principal variations from flatness in the recording process are due to mechanical limitations. In order to provide as high a signal-to-noise ratio as possible, it is desirable that the recorded level on the disc shall approach the maximum permissible value without overloading. Any further discussion of this problem necessitates defining certain recording terms, which will be done shortly.

It may be said, however, that low-frequency equalization is employed to reduce the possibility of overloading and that the high-frequency equalization is resorted to in order to reduce surface noise. The resulting recording curve is one in which the low frequencies are reduced in level at a constant rate, beginning at some predetermined point called the "turnover" frequency, and that the high frequencies are increased in level at some predetermined rate. The high-frequency equalization is commonly called "pre-emphasis" and must be compensated for in reproduction just as the low-frequency equalization is.

Low-Frequency Equalization

There are two basic types of recording. One of these is known as "constant amplitude" and the other as "constant velocity." Both terms apply to the tip of the recording or reproducing stylus as it traces the groove. In constant-amplitude recording, the stylus tip at a given signal level moves a fixed distance each side of its center or rest position for any frequency. Thus the amplitude of the swing of the stylus tip is constant.

In constant-velocity recording, the maximum velocity of the stylus tip at a given signal level remains constant for any frequency. Considering a sine wave as being applied to the recording head, the maximum velocity occuring during each cycle is as the stylus tip is crossing its center or rest position. *Figure* 1 is used to clarify this point. (A) shows a sine wave at a frequency of 50 cps, requiring a period of time .02 sec. in length. (B) shows a sine wave at a frequency of 500 cps, requiring a period of time of .002 sec. Both of these are shown at the same amplitude, or displacement, of the stylus from its rest position. From these diagrams, it is seen that the stylus requires .01 sec. to move from *1* to *2* in (A), and .001 sec. to move from *3* to *4* in (B), and that both of these distances are the same. Therefore, the velocity of the stylus point must be 10 times as great for the higher frequency since it must move over the same distance in 1/10 the time. If the velocity of the stylus were held constant, then the displacement or amplitude of the swing would be re-

[*Continued on page 24*]

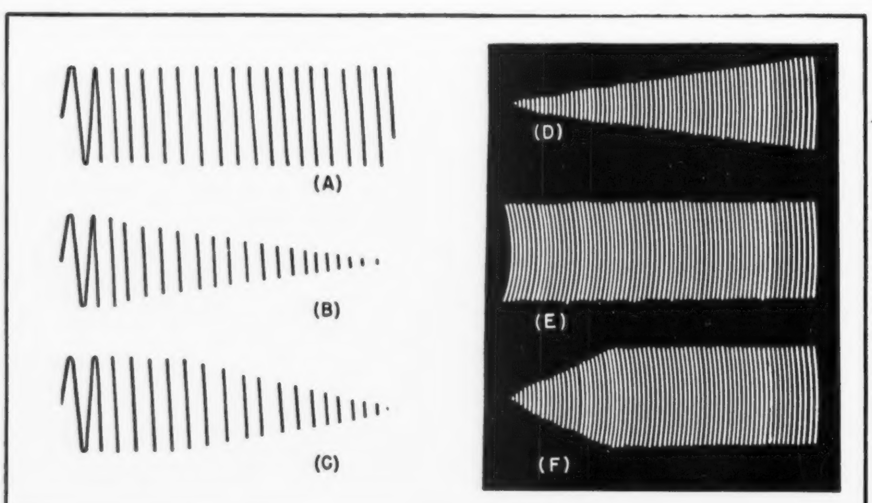


Fig. 2. Amplitude of stylus swing for swept-frequency signal at: (A) constant amplitude; (B) constant velocity; (C) commercial constant velocity. Corresponding light patterns are shown at (D), (E), and (F).

WORKS LIKE NEW! . . . *after 9 months of daily use*

ON 30,000 MILE TREK THROUGH AFRICAN JUNGLE

with Arch Oboler *Famous Radio Playwright.*

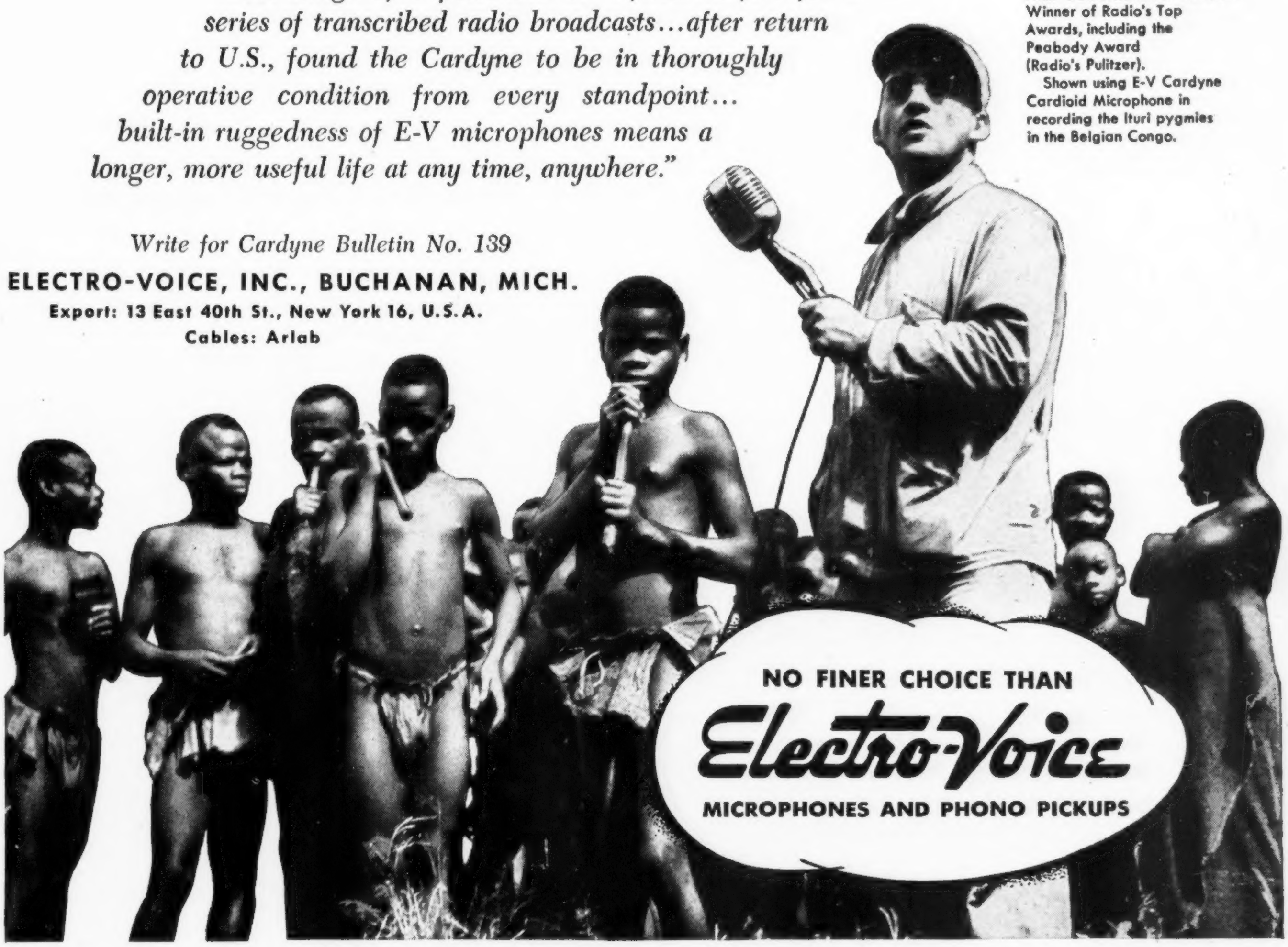
E-V CARDYNE Cardioid Dynamic Microphone takes everything . . . from the heat and humidity of the Congo to the rain-swept slopes of the Mountains of the Moon, to the snow and ice of 16,000 foot Mt. Kenya's glacier fields!

"...trip was made by boat, pack horse, jeep and foot under most difficult conditions...apparatus had to endure penetrating dust and great variations in humidity...used the Cardyne almost entirely...never failed, during months of use and abuse...made recordings of experiences on African safari for a series of transcribed radio broadcasts...after return to U.S., found the Cardyne to be in thoroughly operative condition from every standpoint... built-in ruggedness of E-V microphones means a longer, more useful life at any time, anywhere."

Arch Oboler...Author-Director. Winner of Radio's Top Awards, including the Peabody Award (Radio's Pulitzer).
Shown using E-V Cardyne Cardioid Microphone in recording the Ituri pygmies in the Belgian Congo.

Write for Cardyne Bulletin No. 139

ELECTRO-VOICE, INC., BUCHANAN, MICH.
Export: 13 East 40th St., New York 16, U.S.A.
Cables: Arlab



Fuzziness: Solved!

EDWARD TATNALL CANBY*

STRANGE—AFTER WORRYING for months on end about inexplicable troubles with LP records (until I finally wrote out the whole story, inconclusive as it was, for the October issue) within a week or so I had found really satisfactory answers to most of my questions and doubts. Since then my whole "Department of Long-Playing Records" has been under drastic revision. The prognosis is good. (Thanks to a freak of publishing deadlines, some of the "answers" appeared for me in another journal on the same day that the questions came out in the November AUDIO ENGINEERING. It was not a put-up job—the other journal went to press two weeks later.)

It seems that the answers to the LP problems described are largely in the mechanical, not the electrical sphere, specifically in the fairly obvious matter of stylus compliance. And in that rather simple discovery lies a lot of straightening out in the way of judgments levelled against LP records that more properly should be laid upon the pickup involved in their playing.

Let's get one point straight at once. Of course LP records are heir to all the "normal" troubles of any recording process in the way of electrical distortions, in the original recording, and in the various phases of copying. All of the perplexities, too, of mike pickup and studio liveness apply just as much to the LP as to any other record. Pressing difficulties and the problems of noise crowd in on the LP maker (and the user) just as they always have. Perfection in LP is a bit harder to attain than on 78, but the troubles are the same old troubles, generally speaking. As always, some final results on LP will be better than others. Heretofore it has been my experience that most—indeed, practically all—difficulties of any sort with small-groove records have been ascribed to some one or another of these familiar factors, and notably the supposedly unarguable business of record-curve—which at least for Columbia is a matter of published information. (I've had letters, for example, that suggest my "buzzy distortion" is a matter of wrong equalization.) But right now we are dealing with a special situation and a brand of distortion that falls outside of the regular and familiar areas. Granted there are other LP problems too—but put them aside for the moment. Let's look at just one major trouble.

To review briefly, you will recollect that I discovered, painfully, some strange and irreconcilable phenomena concerning the played sound of LP's. For reasons then unfathomable, LP records that sounded clean with one type of pickup were buzzy, distorted, seemingly grossly overcut when played with a different pickup.

Discovery

The light came via a non-engineer friend (one of those non-engineers whose domicile is filled with enormously professional audio equipment, self-designed). Mr. Frank Robbins, whose profession is art—more specifically at the moment, comic strip creation—listened as had plenty of others to my tale of LP woe; then he casually showed me his GE cartridge. Looked like any other to me. But no. The stylus, it seemed, was a tiny bit different from those I had seen before. I produced my own cartridge . . . yep, the stylus assemblies were definitely different, now that it was pointed out to me. And both were different from still a third stylus that I had also been using. Since I have no official information from GE that these differences even exist at all, let's give them informal monickers. Type 1 (I think the first to appear) has a clear plastic square of damping material under the metal arm (armature). Type 2, the one I had been using all last summer for LP playing and on which many a review had been based, has a round black cylinder of rubber-like material just back of the stylus, replacing the clear plastic damping.

Type 3, the new wrinkle, was scarcely different. The two earlier models (there may have been more) had the twist of the metal ribbon armature about halfway across from the "pin" (magnet) at the center to the stylus. The new type 3 carried the vertically aligned section of the armature *all the way across* to just behind the stylus itself before the twist to a horizontal plane occurred. Closer study showed also a slightly taller black damping cylinder, holding the stylus a bit above and outside the two pole pieces. Tiny insignificant differences, so slight that almost no one I have asked has ever noticed them before.

But, the pay-off. Type 3, Mr. Robbins proceeded to demonstrate to me, all other things being exactly equal, was extraordinarily superior to Type 2 in the very respects that I have been groaning about. Loud, heavily recorded passages, especially near the inner grooves which on stylus 2 "blasted" (sounded fuzzy, broken-up, buzzy, or what have you), on stylus 3 came through clean as a breeze. We tried the experiment again and again, as I have since, with quick plug-in changes from one stylus to the other on the same record. There isn't the slightest doubt about it. The type 3 GE stylus, mounted in the same cartridge that held the type 2 (all of these are of course the replaceable kind) will remove what have seemed to be *a distortion in the record*, but which was actually a distortion due to poor tracking of the stylus, to poor compliance in the stylus assembly. For the first time an inexplicable factor had been pinned down without the slightest doubt to one specific area of trouble—in the stylus itself, *not* in the record.

Withdrawal

It's clear to me now, though I may be wobbly on technical details, that this whole question of the mechanical action of the playing stylus has been grossly neglected by audio enthusiasts and that varying results with small-groove reproduction have been almost universally blamed on the records themselves, ignoring the pickup. Again, the records have their due quota of faults, to be sure; but until you, the user, have determined comparatively just what the various pickup cartridges will do on any given small-groove passage, until you can pin down and so eliminate the variable of differing mechanical characteristics among pickups, you are in no good position to judge apparent or alleged faults in the records themselves. Right?

To conclude on a personal note—at least three quarters, maybe nearer 90 per cent, of the LP records I had formerly judged unsatisfactory in the loud passages and had characterized as "buzzy" or distorted, are now already re-allocated to the "quite satisfactory" category. Many of these have also been the subject of complaints from others than myself. Moreover, until now I have not disposed of a single shellac duplicate of the incoming LP re-issues—I've felt that maybe the shellacs are better, after all, and I'd better hang on to them; as a result of these disclosures I now plan to move out a good proportion of the heavyweight 78's, relying henceforth on their LP versions alone.

Does that indicate the practical importance of stylus compliance?

Note: Here is a rough rule-of-thumb for the three types of replaceable GE styli I have so far observed (there may be more). Their effectiveness increases in this order:

"Type 1": Metal armature ribbon twists from vertical to horizontal halfway across. Damping is a square of clear plastic beneath the armature. Least satisfactory.

"Type 2": Metal armature same as Type 1 (twist is halfway across). Damping changed—a short cylinder of black rubber-like material just behind stylus. Improved, but still tracks badly in .001 model during loudest passages.

[*Continued on page 41*]

279 W. 4th St., New York 14, N. Y.

Constant Groove Depth Solves Microgroove Problem

by D. E. Ward*

Whereas variation in groove depth as small as .0005″ little affects the quality of ordinary disc recordings, such variation seriously impairs microgroove results. The fact that uniform depth is difficult to maintain in cutting ordinary aluminum-base transcription blanks or master discs is borne out by the operating procedures of prominent fine-line recording companies. Recording engineers have found it necessary for fine-line work to select only the flattest discs out of their supplies of blanks. Where fine-line cutting is the predominant phase of their business, so relatively few discs are found to be ideally flat, that excessive inventories of less flat blanks quickly accumulate.

To alleviate this selection problem partially, at least, some recording departments use 13¼″ or 17¼″ discs as originals for even seven inch pressings. Due to the fact that the large master size discs are commonly supplied with .050″ aluminum bases, the *chance* of obtaining a better degree of flatness in these sizes is greater.

On the other hand, however, because of the dependence of all disc manufacturers on only one source of aluminum bases, there is no real assurance that even the heavy bases will be *consistently* flat from shipment to shipment. This fact has doubtless been a contributing factor to what has sometimes been termed inconsistent behavior of ordinary coated discs. When, because of surface run-out, the cut changes from light to heavy once per revolution, surface noise may develop a "swish" which is often erroneously charged to hard and soft areas, a condition which actually never occurs on discs manufactured by modern methods.

The best disc bases obtainable often run out of flat as much as .015″ at a 12″ diameter. The commonly seen wavering of the reflection in a rotating disc is, of course, the plainest evidence of this usual run-out, and is ordinarily the recording engineer's criterion for judgment of flatness.

To eliminate the lost motion of having the user select out the flattest discs himself, and to minimize the resulting accumulation of inventory, one disc manufacturer, REEVES SOUNDCRAFT CORP., now offers a full solution to the flatness problem by new innovations in the familiar Soundcraft line made possible by the Soundcraft Electronic Selector, an ingenious device which rapidly tests discs for compliance with close flatness tolerances. Soundcraft, therefore, now offers two new lines, 'Micromaster' discs for fine-line originals and New 'Microflat Broadcasters' for high quality radio reproduction. *Advertisement.*

*Sales Manager—Reeves Soundcraft Corp.

Electronic Selector Picks Out Flat Discs

by A. C. Travis, Jr.*

To meet the urgent need for flatter-than-average discs for all fine-line applications such as 7″-45 RPM and 33-1/3 RPM LP microgroove recordings, an Electronic Disc Selector has been developed by Reeves Soundcraft Corp. for use in Soundcraft Disc production.

Among the many problems attendant upon the development was the determination of standards and tolerances, in other words, "how flat is flat?" Microscopically speaking, there is, of course, no such thing as a perfectly flat surface. For practical purposes, however, it was determined that even the poorest cutting head suspension would produce a uniform groove at any standard speed if the vertical rise and fall of the surface under the stylus was less than .005″ provided this run-out was not caused by a sharp bend or bump. Flatness testing all sizes of disc bases further determined that the larger diameters, 13¼″, 16″ and 17¼″ averaged flatter than ten and twelve inch bases, which commonly run-out of flat as much as .015″.

Obviously, many ways can be devised for checking discs for flatness, but to check them at production speeds without damage from handling is quite another matter. The disc can, of course, be touched only by the edges, and nothing mechanical can bear against the surface without marring it. The Electronic Selector, therefore, to borrow a political phrase, literally has to "*look* at the record". A combination of optics and electronics, the Selector takes advantage of the fact that the truly flat, broadcasting-quality disc is a perfect darkened mirror. The Selector, therefore, makes use of reflected light beams and photocells to check not only whether the deviation from a truly flat surface is within limits, but also whether the steepness of the curve of deviation is within an allowable tolerance. The Selector makes fast decisions to keep up with Soundcraft's high production rate without sacrificing safety in handling. It would hardly be fair to say that the Soundcraft Electronic Selector is a great invention. The truth is that as a gadget, it is only a new application of prior art. Of *real* importance, however, is the fact that its use makes possible the offer in commercial quantities of remarkably flat recording discs for critical work.

The new selected discs are available in two types: NEW 'MICROFLAT' SOUNDCRAFT 'BROADCASTERS' and 'MICROMASTERS'. The premium-grade Soundcraft 'BROADCASTERS' are now and henceforth being furnished at no extra charge as 'MICROFLAT'. Electronically selected 13¼″ and 17¼″ 'MICROMASTERS' are now furnished for all fine-line originals at a slight increase in price over the popular 'Maestro' line commensurate only with the cost of the selection operation. *Advertisement*

*Vice Pres.—Reeves Soundcraft Corp.

AUDIANA

[*from page 20*]

duced to one tenth of its previous amount, as at (C).

Thus, in a constant-amplitude recording the velocity increases with frequency, although the displacement of the stylus point remains constant. In a constant-velocity recording, the amplitude decreases with frequency, but the peak velocity of the stylus point remains constant. In all of this discussion, it is assumed that the signal level is held at a given fixed point.

Practically all phonograph records and transcriptions are made with a combination of these two characteristics, with the change from one to the other occuring at the turnover point. In order to limit the swing of the stylus at the low frequencies, recordings are normally made at constant amplitude from the lowest frequency up to the turnover point, and at constant velocity above the turnover point. *Figure* 2 shows a typical groove for a swept-frequency signal from 50 to 10,000 cps at constant amplitude at (A), at constant velocity at (B), and at "commercial constant velocity" at (C). Commercial constant velocity is the term given to a curve which is at constant amplitude up to the turnover, and at constant velocity above. If the actual record were viewed with a distant light illuminating the grooves, the pattern due to (A) would appear as at (D); that for (B) would appear as at (E); and that for (C) is shown at (F). This latter is the familiar "Christmas tree" pattern which is almost universally used to evaluate performance of recording apparatus. It is characteristic of this method of illumination that a constant-*velocity* recording will produce a light band of fixed width, and thus the width of the band at any point may be used to compare the actual "velocity" of the groove throughout the frequency spectrum.

Pickup Response

Different types of pickups respond to the recording methods in different ways. A velocity-actuated device—such as a magnetic pickup—will produce a constant voltage output from a constant-velocity recording. This is due to the fact that the voltage is generated by the movement of a conductor through a magnetic field, or by the variation of a magnetic field which passes through a coil. Since the voltage generated in this manner is proportional to the velocity with which the lines of force and the conductor move with respect to each other, the voltage output from a mag-

AUDIO FAIR AUDIENCE ACCLAIMS NEW PICKERING PRODUCTS

. . . declared to be significant achievements in the audio art

Thousands of engineers, musicians, audio enthusiasts and music lovers were unanimous in their enthusiastic approval of the new Pickering loudspeaker, preamplifier, record compensator and pickup arm, all of which were shown to the public for the first time at the recent Audio Fair. The extraordinary acceptance by this critical audience confirms the soundness of the basic design of these new products. All of these audio components were developed for the exacting listener; the psychological factors associated with listening were given as much weight as the measurable quantities, such as frequency response, intermodulation distortion and transient response. It is comparatively easy to design equipment which measures good. It is not at all easy to produce audio equipment which sounds good. The successful realization of this fact is largely responsible for the absence of "listener fatigue" in Pickering products.

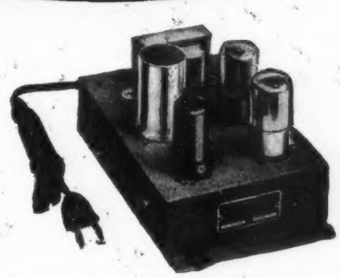
Pickering High Fidelity Components — speaker, preamplifier, record compensator, pickup arm and pickup cartridges are available through leading jobbers and distributors everywhere . . . detailed literature will be sent upon request.

NEW LOUDSPEAKER MODEL 180L

designed to satisfy the musical ear. A low-cost high quality loudspeaker with smooth wide-range response (within 5 db, 45 to 12000 cycles) and low distortion . . . the only loudspeaker with acoustically adjustable bass response . . . occupies less floor space than any other high quality loudspeaker — less than one square foot.

NEW PREAMPLIFIER MODEL 130H

This preamplifier represents the most advanced design ever achieved in phonograph preamplifiers . . . it equalizes the bass response of records and transcriptions and provides the necessary gain for high quality magnetic pickups . . . its intermodulation and harmonic distortion is exceptionally low —better than most professional equipment.



NEW RECORD COMPENSATOR MODEL 132E

This compensator, with 6 positions of equalization, provides the flexibility required to properly equalize for the different recording characteristics used by various record manufacturers . . . it is a most important addition to any record playing system using magnetic pickups.

NEW

PICKUP ARM — MODEL 190

The only arm specifically designed for optimum performance on both microgroove and standard records.

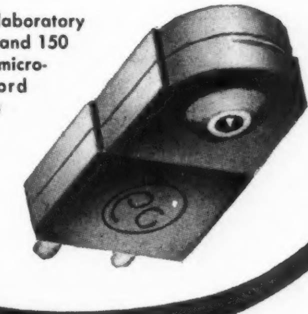
- Statically balanced to eliminate tendency to skip when jarred.
- Minimum vertical mass to track any record without imposing extra vertical load on grooves.
- Sensitive tracking force adjustment.

- Magnetic arm rest.
- Rugged frictionless bearings.
- Plug-in cartridge holder.
- One-hole mounting — self-contained levelling screws.

Cartridges used with this arm require 50% less vertical tracking force than, when used in conventional arms.

PICKERING CARTRIDGES SERIES 120, 140 AND 150

For broadcasting, transcription and laboratory use, and for home playing. Series 120 and 150 for standard records . . . Series 140 for microgroove records . . . the optimum in record response for discerning music lovers who want all of the realism and brilliance originally recorded. They track with phenomenally low record wear and virtually eliminate harmonic and intermodulation distortion as well as frequency discrimination . . . available with either sapphire or diamond stylus.



Pickering & Company, Inc.

Oceanside, Long Island, N. Y.

netic pickup is flat over the constant-velocity portion of a recording, and droops at the rate of 6 db per octave over the constant-amplitude portion of the recording. Conversely, the voltage output from a crystal pickup is flat over the constant-amplitude portion of the recording, because the voltage generated by a crystal pickup is directly proportional to the *displacement* of the crystal, which is in turn actuated by the stylus.

There are a number of other factors which enter into the actual voltage output from a pickup, but these are functions of the mechanical characteristics of the device. The masses and compliances of the stylus and its supporting structure, of the pickup arm, and of any other moving elements, affect the output by introducing mechanical resonances which show up as peaks and dips in the frequency response of the pickup.

To clarify one point, however, it must be said that if a recording were made with a crystal cutter without any equalization, and played back with a crystal pickup, also without equalization, the output would be exactly like the input, provided both cutter and pickup were perfect. Similarly, if a recording were made with a magnetic cutter without equalization, and played back with a magnetic pickup—also without equalization—the output would again be exactly like the input, assuming that both pickup and cutter were perfect. However, pickups and cutters are not perfect, and in addition, the equalization previously referred to is normally applied, so some equalization must also be applied in the reproduction.

Equalization Required

Practically all commercial recordings are made with magnetic cutters, and consequently there is a certain amount of equalization introduced to limit the excursion of the stylus, during the recording, up to the turnover point. Thus the recording is constant amplitude up to this frequency, and essentially constant velocity above. Therefore, the reproduction by a crystal pickup is flat from the lowest frequency up to the turnover point without any equalization, and droops at the rate of 6 db per octave above that point. This demands that crystal pickups be equalized on the high end only, since it is a characteristic of these devices that they reproduce flat from a constant-amplitude signal. In order that they should actually be flat over the low end, the equivalent circuit of a crystal pickup as a generator must be investigated. The crystal may be considered as a constant-voltage generator in series with a capacitance equal to that of the pickup itself. This

capacitance is of the order of .0015 μf, and therefore the load resistance must be chosen so that there is adequate transmission of the low frequencies. The circuit may be likened to that of the coupling capacitor between two amplifier stages, and it is remembered that the size of the capacitor affects the low-frequency response.

The capacitor and the grid leak or load resistor may be considered as a voltage divider, with the reactance of the capacitor acting as the top section and the load resistance as the lower, as shown in *Fig.* 3. At the frequency where the reactance of the capacitor equals the resistance of the load resistance, the response is down 3 db from the maximum. This accounts for the requirement that the load resistor for a crystal pickup shall be relatively high in value, usually at least 0.5 meg, and in many instances more than this. It also accounts for the statement that the low-frequency response may be controlled by the value of the load resistor.

To equalize the response above the turnover point, some arrangement similar to that of *Fig.* 3 (B) is generally

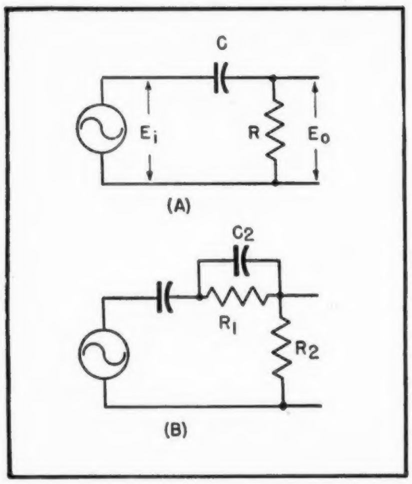


Fig. 3. Crystal pickup circuits. (A) is equivalent circuit when crystal pickup having capacitance *C* works into the load resistance *R*. (B) shows usual method of compensating for high-frequency droop.

employed. Assuming that the turnover frequency is 500 cps, the response at 1000 cps is down from the 500-cps level by 6 db; at 2000 cps it is down 12 db; at 4000 cps it is down 18 db; and at 8000 cps it is down 24 db. Thus if it is desired to equalize completely up to 8000 cps, it is necessary to introduce 24 db of loss to the low frequencies by means of a voltage divider R_1 and R_2. This requires that $R_2/(R_1 + R_2)$ must equal 1/16, since this is the voltage ratio corresponding to a 24-db loss. Then, the low frequencies are reduced in level to the 8000-cps level, but this

would also introduce a similar loss at 8000 cps, so this effect is counteracted by shunting a capacitor across R_1 with its reactance at the 3-db point being equivalent to the resistance R_1.

Considering actual and typical values, let us assume that R_2 is taken as 0.1 meg; therefore, R_1 must be 0.1 meg. x (16−1), or 1.5 megs. For the case under discussion, the curve is flat at 500 cps, and down 6 db at 1000 cps. By drawing this curve on a sheet of graph paper, it will be observed that the curve is down 3 db at approximately 700 cps. Thus it is determined that the reactance of the capacitor C_2 must equal 1.5 megs at a frequency of 700 cps. The actual value of the capacitance may then be calculated from the relation $C = 1/2\pi fX_c$, or it may be obtained from an inspection of a reactance chart (such as that on page 13). In this case, the required capacitance is approximately 130 $\mu\mu$f, and this value will give complete equalization for a crystal pickup at high frequencies up to 8000 cps, when used with these resistance values.

There is just one thing wrong with this equalization, however. Records are not normally cut with a flat frequency response all the way up from the turnover point. The NAB curve, for example, as well as the standard LP curve, are both cut on the basis of a pre-emphasis of 100 μsec, of which more later. With this curve, then, the recorded signal is already boosted by approximately 14 db at 8000 cps, and the required equalization is thus reduced to only 10 db at this frequency, and the calculations must be revised.

This discussion should give a rough idea of how equalization is arranged for one type of pickup. Let it be said that if the response of any given pickup is known for a flat frequency record, it is fairly simple to determine exactly the equalization required to obtain flat response. It then becomes necessary to know the exact recording characteristic in order to make a good match. These characteristics differ appreciably, although there are a number of more or less definite curves in common use today.

Turning for a moment to the magnetic pickup, it will be remembered that the response for constant amplitude recording droops at the rate of 6 db per octave below the turnover point. This requires a boost of the low frequencies, in direct contrast to the crystal pickup, but for a flat recording above turnover, no high-frequency equalization is required. Actually this does not obtain in practice because of the pre-emphasis employed, and some high-frequency droop must be introduced intentionally.

Low-frequency equalization for magnetic pickups may be obtained in a variety of ways, all of them about equally effective, but differing appreciably in circuit design. The output signal from these pickups is usually quite low—ranging from 10 to 100 millivolts—and some amplification is required to boost the signal up to the level of radio tuner outputs, in order to facilitate switching. The common methods of equalization for magnetic pickups will be discussed in Part II of this series.

CATHODE FOLLOWER

[*from page 15*]

in A if an additional stage is included within the feedback loop.

If we add such a stage to the cathode follower (as in *Fig.* 5) we run into the same problem of ground reference for our input signal that we had with *Fig.* 3B and encounter rather serious power supply problems for this stage. If, however, we had a stage within the feedback loop for the conventional amplifier (as in *Fig.* 6) we would then have a solution to the problem which would provide the same improvement in

damping impedance and distortion achieved in the cathode follower, without requiring excessive signal voltage to drive. In other words, if we wish to design an amplifier with the advantages of the cathode follower, but which does not require excessive drive, we need

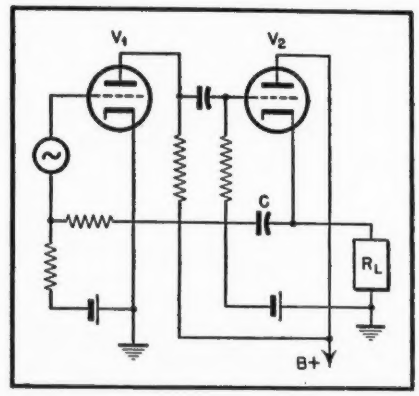


Fig. 5. Cathode follower with additional gain stage. Capacitor C may be omitted and direct coupling used in the feedback loop.

merely use a conventional amplifier with feedback from the plate and the same $A\beta$ factor as the equivalent cathode follower. Additional overall feedback may of course be used from the voice coil, precisely as in a well designed amplifier using cathode followers.

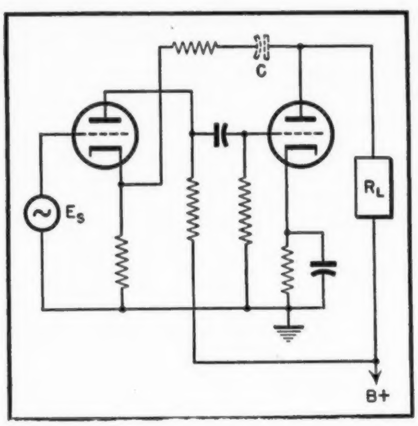
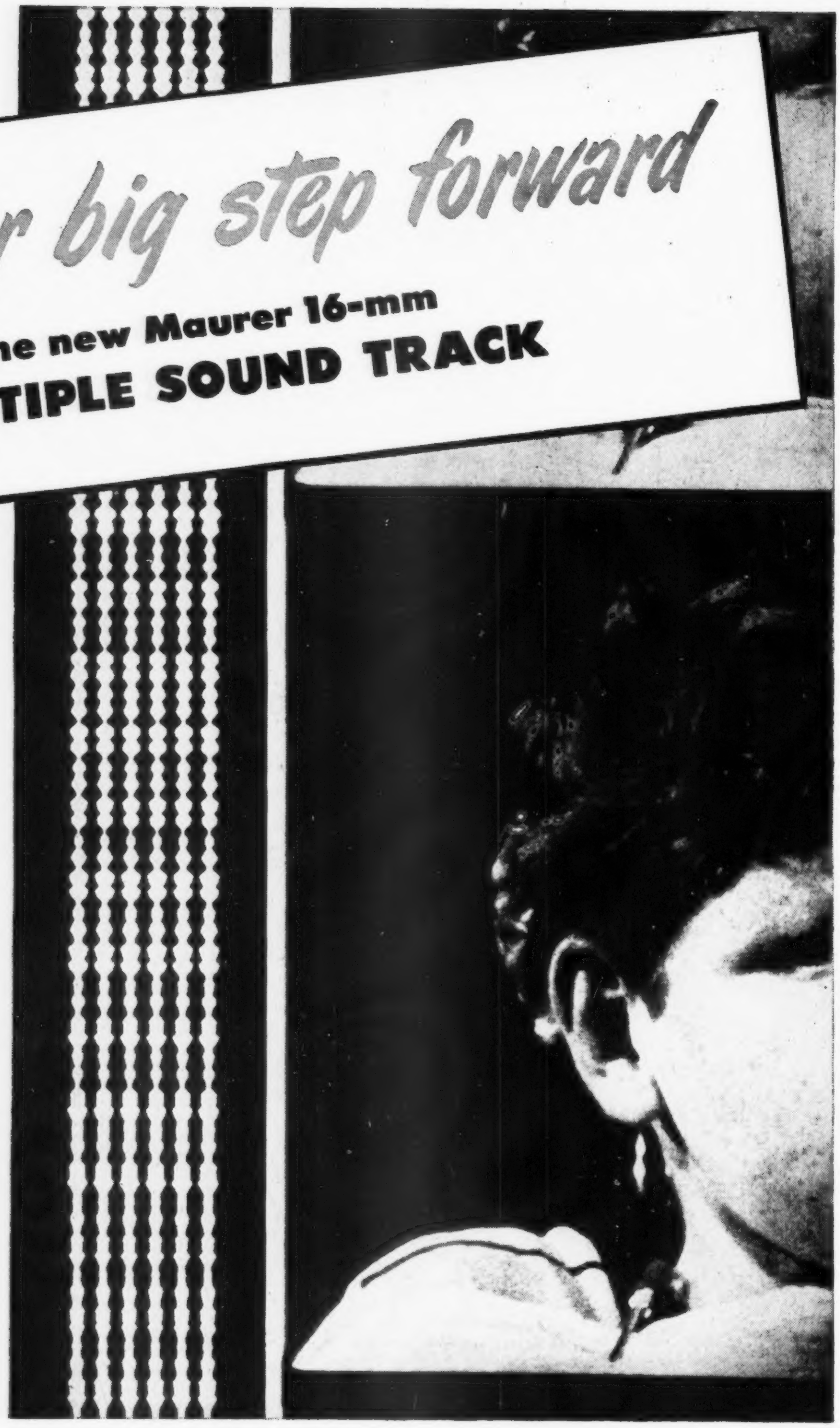


Fig. 6. Conventional feedback amplifier. If $A\beta$ is equal to that of cathode follower, it will have the same impedance characteristics. Capacitor C may be necessary to maintain proper d.c. relationships.

We have shown, therefore, that a cathode follower is simply a feedback amplifier wherein $A\beta$ is determined more or less automatically without any effort at design, but that other configurations can give identical results without the attendant disadvantages. The circuit of *Fig.* 6, familiar as it is, will provide more generally satisfactory results than the cathode follower, if subjected to the same feedback criteria.

Another big step forward

the new Maurer 16-mm MULTIPLE SOUND TRACK



The average 16-mm sound projector introduces an appreciable amount of distortion into the playback of the usual bilateral variable area sound track.

Recent surveys have indicated that the amount of distortion so introduced by nonuniform illumination of the scanning light beam ranges up to 30 per cent. A maximum of 10 per cent is generally considered allowable in 35-mm reproduction.

The new Maurer multiple track, by replacing the usual single track with six, reduces the amount of this projector-introduced distortion to values of about 5 per cent—which is very good performance.

No changes in processing or in projection equipment are involved. The only change is in the recording galvanometer.

The very substantial improvement is quickly evident to the untrained listener as well as to the engineer.

Write for more complete information.

The new Maurer Recording System, incorporating the six-track galvanometer, will be commercially available early next year.

In line with the Maurer policy of protecting its customers against obsolesence as far as is possible, all owners of the Maurer Model E System will be invited to convert their equipment to the new six-track recording, at a cost which will not exceed the difference between the initial costs of the two systems.

16mm maurer

J. A. MAURER, INC.

37-03 31st Street, Long Island City 1, N. Y.

16-mm Professional Production Equipment

BELOW 50 CYCLES

[*from page 18*]

It is this mechanically stimulated feedback which finally limits the amount of low frequency amplification. The loudspeaker described utilizes a high value of resistance and acoustical capacitance to stiffen the vibrating cone. The load resistor shunting the speakers together with the crossover dip reduces the tendency toward feedback. Notwithstanding these measures, the full gain of the bass amplifier could never be turned up unless the speaker were located in some other building. At times during these investigations, footsteps on a thick rug caused a "thump" in the speaker. When the gain is turned just below feedback, almost any action in the room will result in a "bloop." However, for all rational and most irrational enjoyment of bass program material, the amount of gain required will be far below feedback.

On Speakers Generally

There is probably more misinformation the subject of loudspeakers than in any other branch of the communication art. In spite of manufacturers' ratings, few 12- and 15-inch cone speakers can reproduce 50-cps within 10 db of their output at 100-cps. Manufacturers' specifications for low-frequency cut-off probably means that their product will respond to this frequency within 10 of 20 db of the piston range level. Furthermore, the prevalent notion that one merely has to utilize a larger cabinet or baffle to increase lows is not strictly true. Beyond a certain volume there is insignificant improvement, as can be attested by the disappointment of those who have mounted speakers in the door of closets or even in the wall between rooms. In order to reduce the resonant frequency by one octave, the total stiffness must be reduced by a factor of four. The formula for resonant frequency shows that this varies inversely as the *square root* of all stiffness factors, the stiffness contributed by the cabinet enclosure being only one of many factors. The mechanical stiffness built into the cone rim and spider which operate below resonance is the largest factor, and over this the constructor has little control. The natural resonant frequency of a typical 12-inch cone, rated to handle 10 watts of audio, is between 70- and 80-cps as measured in a flat baffle of practically infinite size.

Speakers can be designed for 50-cps

on a flat response basis, but this usually means a severe sacrifice in power handling ability and the use of an extremely large magnet. The compliant rim of the cone must be made thinner or more flexible in order to reduce the mechanical stiffness. Hence, the power handling ability and the life of the cone are reduced. Further, it must be capable of movement to extreme amplitudes under linear force, and the voice coil must remain in a uniform high-density flux field. Speakers of 12- and 15-inch diameter, as popularly made, have a voice coil length (winding length) of approximately .300 inches. To maintain such a voice coil within a field of uniform magnetic flux means that (for 10 watts excitation and 5 per cent efficiency) the axial gap length in the magnetic circuit must be about .600 inches at 50 cps. For a given flux density, the weight of the magnet will be proportional to the *square* of the increase in gap volume. This results in a magnet so costly as to place it outside the competitive field, a disastrous prospect for most manufacturers. It is widely considered in the speaker industry that high flux density in a long axial gap is so costly as to be hardly justified by what is thought to be only a slight increase in musical value. One of the most reputable 15-inch woofers on the market today—one selling for over $100.00—has an axial gap length of only .400 in. Probably also the problem of designing a suspension system that has uniform high compliance over a .600 in. total displacement is rather formidable and discouraging, to say nothing of the need for adequate restoring force.

To the author, the logical solution was the use of a stiffness-controlled speaker system, driven by brute force to overcome the low-frequency deficiency of conventional cone speakers. By using four speakers, the input power is divided, and each speaker operates at reduced amplitudes, holding distortion to a minimum. The effective piston diameter is increased over that of a single cone, thus maintaining radiation resistance to a lower frequency and hence improving the efficiency.

In selecting speakers, it is not necessary that they be so-called woofers, assuming such can truly be found. It is only required that they have high conversion efficiency. The magnets in efficient cone speakers should weigh at least 16 ounces if Alnico V, or about 4 pounds if Alnico I or II. Actually, the grade of Alnico or other magnet material is unimportant so long as a flux density in excess of 10,000 gauss is realized in the gap. Voice coil diameter should preferably be at least two

inches. Large diameter voice coils exert a more uniform driving force to all surfaces of the cone, and besides handling more input power, may possess less distortion at high amplitudes. An attempt was made to select speakers having slightly different resonant frequencies to avoid an accentuated peak. Peaks and dips, inherent in all speakers, occur at slightly different frequencies in each speaker. When such speakers are combined in a group, the final output will be characterized by smoother response, the dips virtually disappearing.

Book Review

Acoustic Measurements by Leo L. Beranek, S.D., D.Sc. (Hon.) Associate Professor of Communication Engineering and Technical Director of the Acoustics Laboratory, Massachusetts Institute of Technology. John Wiley & Sons, Inc., New York, $7.00.

Specific details on measurements in the field of acoustics have seldom been published outside of technical journals and mathematical treatises. This book, therefore, fills a much needed place in the literature of the science of acoustics. It is, as the author states in his preface, "primarily . . . a reference for graduate students and workers in the field of acoustics."

The first two chapters deal with the history and terminology of acoustics and mediums for the transmission of sound, with special attention being given to air and water. In the discussion of the medium are found the wave equation, diffraction, scattering, and non-linearity of the medium. Chapter Three details, both in theory and practice, the disturbance of plane sound waves by obstacles and by finite baffles. Included are analyses of the human body in a sound field and the behavior of loudspeaker baffles. In only sixty-six pages of the fourth chapter appears the most complete discussion of the absolute calibration of microphones ever presented. The most popular method used today, the reciprocity technique, is analyzed in terms of its electrical analogy and is then developed for the acoustical case.

The next eight chapters cover individual acoustical elements; among them are microphones and the ear, measurement of frequency, measurement of acoustic impedance, the audiometer, sound sources for test purposes, characteristics of random noise, indicating and integrating instruments for the measurement of complex waves, and analysis of complex waves.

The last eight chapters describe completely the methods of testing communication systems from the microphone through acoustical enclosures, concluding with sound level meters.

While Dr. Beranek has reduced much of the mathematical complexity usually associated with works on acoustics to a reasonable series of lucid expositions, he still uses calculus at the level of engineering graduate students. Nevertheless, this book should find a place in the library of all laboratory and research workers.

50-WATT AMPLIFIER

[from page 11]

the application of the d.c. plate supply between these coils.

Figure 6 (A) illustrates a further step in the development of the final circuit and shows a cathode-loaded arrangement with a required plate supply isolation reactance. Here it will be seen that the cathode loading results from the method of drive. For instance, tube *1* is driven from the control grid to the far side of its load which is, from an a.c. standpoint, at the same potential as its plate, and similarly tube *2* is driven in a like symmetrical manner. In order to drive the stage, it is necessary to do two things: to provide an input transformer or similar device and to provide an isolation reactor which has sufficient impedance to keep the plate supply and the amplifier stage isolated from an a.c. standpoint. It will be seen here that the entire stage is floating with respect to ground. At points *A* and *B* in *Fig.* 6(A) it will be noted that the full voltage developed across the output stage appears to add to the difficult problem of designing a driver transformer able to handle the large voltages needed to drive the output stage. These difficulties—as well as the requirement for wide frequency range, balanced couping, and high impedance primary—make this transformer somewhat impractical if not impossible.

Deleting the isolation reactors from the circuit of *Fig.* 6(A) gives the circuit of 6(B) in which the two cathodes remain at the signal potential difference of the output transformer primary, but one cathode has been returned to ground while the other is left floating. Again the design of an input transformer is highly impractical.

An attempt, therefore, was made to get away from the four-terminal input circuit required by *Fig.* 6(B) and go back to the conventional three-terminal input if at all possible. This was accomplished by the circuit as illustrated in *Fig.* 7, which is similar to those of *Fig.* 6 except that instead of driving the stage fully cathode loaded, the point *A* of *Fig.* 6(A) was connected to the mid-point of the cathode winding which, of course, suggested that point *B* be connected to that same cathode midpoint. We now, therefore, have our three-terminal conventional drive circuit, and furthermore we find that this mid-point can be grounded, which immediately suggests that the plate supply can be similarly attached to the midpoint on the plate winding of the output transformer, and finally this elimi-

nates the need for the isolation reactors.

Concentrating first on the output transformer primary and taking for instance the a.c. current path from the plate supply at + upwards through the winding and to the plate of the lower tube, thence from its cathode through its winding to the center point and therefore back to the power supply, we have utilized one plate winding and one cathode winding on opposite halves of these coils. Considering the upper tube, we find a similar situation. It is seen that half of the output winding is in the cathode circuit and half is in the plate circuit for each tube, but since the two windings are coupled tightly from an a.c. standpoint, they become practically identical, and therefore we have an output stage which utilizes

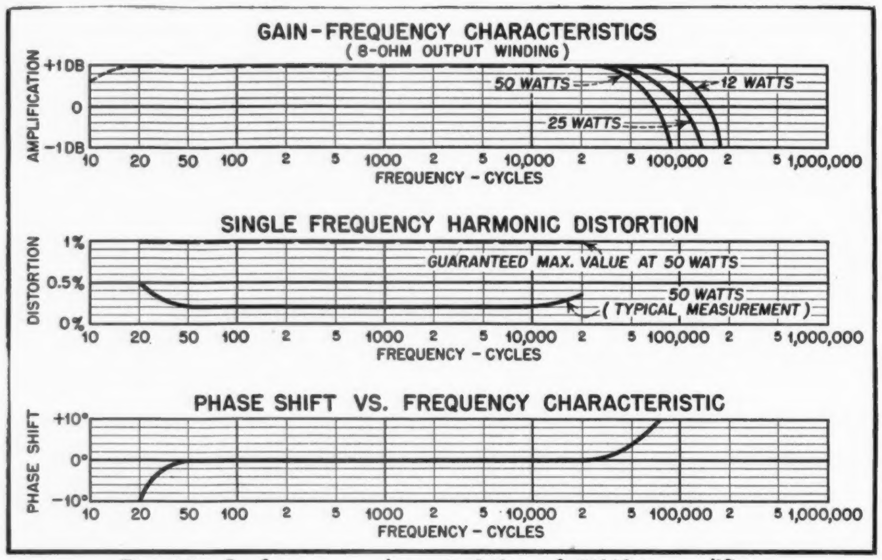


Fig. 10. Performance characteristics of 50W-1 amplifier.

essentially the same primary windings. Since this is so, it is obvious that there can be no leakage reactance between the output coils for the two tubes. In addition to the compatibility now possible between high efficiency and high quality, there are several other advantages of this circuit arrangement which are described.

Circuit Advantages

It is convenient with this circuit to use either pentodes or triodes. *Figure* 7 shows the screen grid connected in a suitable manner to make use of the inherent efficiency in power conversion of pentodes or beam power tubes. The requirement that the screen be kept at a constant d.c. potential *with respect to the cathode* is fully met by virtue of the fact that the two windings are coupled so tightly that no a.c. potential can develop between the cathode of either tube and its corresponding screen. It is obvious also that a constant d.c. potential equal to the plate voltage, in this case, is provided for the screen. *Figure* 8 illustrates a simplified equivalent circuit of *Fig.* 7 that may clarify the use of the 'take turn' primary idea.

Referring back to *Fig.* 7, some of the additional advantages of these circuits will be described. The impedance between the tubes is now 1000 ohms instead of 4000 ohms shown for the conventional circuit in *Fig.* 1. The impedance between either side and ground is only 250 ohms instead of 1000 ohms. This 4-to-1 impedance reduction between the tubes reduces the effects of stray capacitances by a factor of 4, permits a wide extension of the audio pass band, and reduces the phase shift of the fundamental and the harmonics. Furthermore, since the two primary windings now look like one winding to the secondary, the effective turns ratio has been reduced by a factor of 2 to 1 between primary and secondary. This results in a 4-to-1 coupling advantage over the circuit shown in *Fig.* 1. Since both the shunting capacitance impedance advantage of 4 and the coupling advantage of 4 occur simultaneously, there is inherently a 16-to-1 advantage in this circuit over the conventional circuit. This advantage obtains regardless of the class of operation of the tubes. Therefore, not only has the barrier been crossed to permit the use of high efficiency at low distortion, but at the same time a substantial improvement in circuit characteristics has been found.

Figure 7 also shows that some direct-coupled negative voltage feedback is used. It will be seen that since half of the load is in the cathode and half of the load is in the plate, as before mentioned, almost the entire gain in this final stage is lost by virtue of the feedback resulting from this method of loading. Additional feedback is achieved by connecting suitable resistors between the cathodes of the output tubes and the cathodes of the phase inverter stage. This combination of feedback results in improving the linearity of the amplifier and permits the manufacture of amplifiers on a regular production basis which can be guaranteed to have less than 1 per cent distortion over a wide range of frequencies.

This feedback also reduces the internal generator impedance to a value approximately one-tenth of the referred load impedance. This means that the output circuit, say the 8-ohm winding, looking back into the amplifier would be 8/10th of an ohm. This low generator impedance provides two desirable characteristics.

Low Output Impedance

It is obvious that if the impedance of the load device—such as a speaker—should change, as it usually does over the range of frequencies for which it is used, then the effective amplification will likewise change, resulting in a limitation of the power output or serious distortion, or both. Therefore, it is important in the design of an

amplifier that is to be used anywhere but on a test bench and working into a resistance load, that it should be made as free as possible of the effects of load impedance in order that the design performance of the amplifier can be realized in actual practice. The 50W-1 amplifier for all practical purposes isolates the effect of the load on the effective amplification of the output stage because of this low value of generator impedance. Furthermore, the tendency of the load device to continue motion after the initiating signals have ceased is effectively damped. This means that any back e.m.f. generated by the load device sees such a low resistance looking back to the amplifier that the counter e.m.f. resulting from this low resistance dynamically brakes the load device and quickly damps out any free oscillation. Theoretically there is no minimum limit to which this internal generator impedance can go to act as a benefit in both of the principles above mentioned. However, going from the damping factor of ten to zero for the use in audio devices produces only a minute improvement in damping since the load devices do not approach 100 per cent efficiency. For some applications the internal generator impedance has been made 1/100th of the nominal impedance.

One of the apparently conventional features of the amplifier is the driver transformer for the output stage. Since the direct current drawn from the power supply by the Class B stage is proportional to the input signal level, and since the power supply internal resistance can not economically be made to approach zero ohms, there will be a change in plate voltage with a change in input level. At best, change in level of a single-frequency signal from zero to full output, the change in plate voltage cannot be made less than 25 volts. If the driver plate voltage were to be derived from this varying source and the driver were resistance-capacitance coupled to the control grids of the Class B amplifier tubes, the change in plate voltage would appear as a change in bias adding to the bias for an increasing signal and subtracting from it for a decreasing signal. A 15- to 30-volt increase in bias voltage would shift both output tubes toward Class C operation and consequent current cutoff during both crossover periods for a length of time depending on the duration of the change in level and the time constant of the resistance-capacitance coupling circuit. The increase in bias signal level change will appear as transient distortion. To avoid this source of distortion either separate power supplies or transformer coupling is required be-

tween the driver and the output stage. The design of a high-impedance push-pull transformer along conventional lines is another impractical problem. To keep waveform distortion and current consumption low in the driver stage, the primary impedance of the driver transformer must be kept above 100,000 ohms from 20 cycles to 30,000 cycles. The response of the transformer from primary to secondary should not show more than a 0.1 db variation from 18 cps to 30 kcs in order to function within a second feedback path in the amplifier. All of these requirements were met by resorting again to the bifilar construction where the input windings are wound together, giving practically 100 per cent coupling independent of frequency.

Figure 9 shows the schematic diagram illustrating the 50W-1 watt amplifier including the phase inverter, volume control and preamplifier. It will be seen from this circuit that the driver output stages are similar to those diagramed in *Fig.* 7. The output transformer provides for 4, 8, 16, and 32 ohms balanced or unbalanced, as well as 600 ohms balanced. It will be noted that the 600-ohm tap is taken off the primary winding connected to the cathodes of the output stage, and since this winding is grounded at its midpoint, neither of these taps (7 and 8) can be grounded. If required, a 600-ohm winding can be supplied separate from any of the other windings of this transformer.

The amplifier is designed in a manner similar to that described for the power supply, namely, that the driver coil and output coil are potted in the box forming the unit, that the top includes a number of sockets which are interwired to provide the proper circuitry and the other elements plug into these sockets to provide the proper amplifier arrangement. This permits easy "substitution method" servicing, fixes the relative position of components, providing for better uniformity in manufacture and permits unusual arrangement features. For instance, the input level to the amplifier is approximately zero db when connected into the phase inverter. The plug-in "preamp" provides an additional 34 db gain, and a triple-shielded input transformer provides an additional 20 to 30 db depending on which input connection is used 30, 150, 600 ohms or bridging input. A control console is available which includes tone control, additional preamps and necessary switching for microphone, phonograph, and radio inputs. An equalizer-amplifier which follows the NAB recording curve and with a gain of 20 db at 1,000 cycles may be plugged into the unit.

Figure 10 illustrates the average performance characteristics of the amplifier. The gain-frequency characteristics may seem abnormally wide, but since it was desired to provide a manufactured product which could be guaranteed to deliver 50 watts at any frequency from 20 to 20,000 cps with less than 1 per cent harmonic or intermodulation distortion, this wide band was found necessary to keep the phase shift reasonably low so that the feedback of the higher fundamental frequencies and their harmonics would be in proper phase relationship to cancel out, and therefore improve the linearity of the amplifier. If the phase shift at the pertinent harmonics is 90 deg. or more, no benefit is obtained from feedback, and since the feedback varies inversely from one at zero deg. phase shift to zero at 90 deg. approximately as the cosine of that angle, it is seen that quite large phase angles are associated even with relatively small losses or variations in the gain-frequency characteristic. For instance, a change in response from 0 db to 0.1 db is inevitably associated with 10 deg. of phase shift. A change from 0 db to 3 db is always associated with a 45 deg. phase shift. It is instantly obvious that if these variations occur at the fundamental, they are substantially more at the harmonic frequencies and, therefore, the effect of feedback is reduced in proportion to

the cosine of these phase shift angles. In some cases this may cause instability of the amplifier, particularly where large amounts of feedback are used. Experience has shown that the phase shift begins to be measureable at values 1/7th to 1/10th of the frequency at which the 2 db point shows up on a gain-frequency characteristic. Therefore, the designed bandwidth should be from 7 to 10 times the highest frequency for which it is desired to have distortion less than 1 per cent. The figure shows that the phase shift through the amplifier is substantially zero from 30 to 30,000 cps.

The circuit here described in part appears to open new fields of use or improvement in present fields permiting operation very near the theoretical maximum efficiency and yet provides a high degree of linearity with high stability for either impulse or steady state signals.

USING THE REACTANCE CHART

[*from page 13*]

R substituted for X_c the equation becomes

$$f = \frac{1}{2\pi RC}$$

This equation will be recognized as the equation for the rejection frequency of the parallel-T filter, such as is shown in *Fig.* 4 providing $C_1 = C_2$ and $R_1 = R_2$ with R_3 and C_3 properly proportioned. This filter is electrically equivalent to the Wein bridge shown in *Fig.* 5; consequently, the chart may also be used to determine the null frequency of such a bridge, or the frequency of an oscillator employing the Wein bridge for the frequency-determining element.

Thus, it has been shown that the conventional reactance chart may be used without modification for determining component values for the low-pass filter prototype if the values of L and C read from the chart are taken for $L/2$ and $C/2$. In the case of the high-pass filter the values indicated by the chart are twice the values given by the filter equations. The value of the series elements of a parallel-T rejection filter or Wein bridge, such as is used frequently in oscillators, are indicated directly on the chart.

Although graphical methods are not recommended for highly accurate work, the results obtained by using the chart are sufficiently accurate for many engineering applications.

RECORD REVUE

[*from page 22*]

"Type 3": *Metal armature changed—vertical alignment goes all the way across, twist to horizontal being just back of stylus.* Damping is same black, rubber-like cylinder but taller, holding stylus higher. Greatly improved results, both .003 and .001, but particularly with the .001 LP stylus. (Compliance obviously increased by the longer vertical section.)

Beethoven, Symphony #9 ("Choral").

a) New York Philharmonic, Bruno Walter
Columbia LP: SL 156 (2)
78: MM 591 (8)

b) Philadelphia Orchestra, Ormandy
LP: SL 150 (2)
78: MM 900 (8)

● The Ormandy "Ninth," with the Westminster Choir, came out originally at the end of 1945, one of the first post-war releases. It reappeared in the LP form soon after the new records were introduced. Now Columbia brings out another Ninth, also on LP (both are available on standard records in 8-record albums), a fairly good indication that the LP record has come to stay; for recordings of the Ninth symphony, with its large orchestra, huge chorus and soloists, are few and far between and have always constituted monuments, or would-be monuments in the art.

The comparison is interesting here because the older version is actually quite up-to-date in the technical sense, with adequate tonal range and excellent acoustics—this is no replacement for "modernization" but strictly a musical matter, or so it would seem. There is no doubt about it at all: though the Ormandy-Philadelphia version is a good conscientious job, the Bruno Walter performance is a tremendous one, perhaps as good as the finest heretofore, the ancient and honorable Vienna Philharmonic recording under Weingartner, well into its later 'teens by now, I'd guess. It is impossible to say in a few words here exactly what the musical difference is, except to suggest that the Walter version, like all of his Beethoven, is not only the result of an almost fanatical dedication to Beethoven's music and a long life-time of study and performance of it, but it is, judging by the sound, also the product of a lot more careful rehearsal than the Ormandy. (If not, then Walter is an even bigger musician than I'd thought.)

The Walter Ninth uses the same chorus —the Westminster Choir—as the Ormandy, but the singing is definitely better, more precise, more focussed (in a work which is almost unsingable for chorus at best). The Ormandy soloists are super-mediocre; the Walter soloists are good to excellent (though again, no human soloist could sing the Beethoven music more than approximately perfectly!). In the first three movements, without voices, the Walter version is tempestuous and taut, or utterly serene, always in greater measure than the Ormandy—all of which could be illustrated by a thousand and one details in the music itself, could it somehow be played along with this article.

Technically the two Ninths are not far apart, the most vital difference (in the LP versions) being the mode of division of the

movements on the three records sides required. To my mind the old one has the best scheme. In it, the long and violent first movement occupies the whole first side; the equally violent scherzo (with tremendous tympani explosions gets favorable placing at the start of side 2; the long slow movement, never very loud, is adequately squeezed onto the rest of side 2. The new Walter version puts both violent movements, first and second, on side 1. The result is a tight fit, omitting repeats in the scherzo that should not be omitted. In order to accomodate the tympani bursts and the rest of the scherzo's violence the whole level is lowered. I don't like it, and the supremely fine sound of the slow movement, with side 2 all to itself, doesn't quite repair the damage.

Beethoven, Symphony #3 ("Eroica").
New York Philharmonic, Bruno Walter.
Columbia LP: ML 4228

● Just in time for inclusion in this issue, comes still another in the remarkable series of Beethoven recordings by Bruno Walter now appearing at intervals from Columbia. The Ninth (above) is the most impressive one yet—it always makes a big splash when it appears in any form—but the Eroica is an even better job. For not only it it a superb performance, but the recording is definitely a step better than that of the Ninth. Reasons are easy to guess at.

The Ninth is not only almost a superhuman job of performance, but it is a nightmare for the engineer—what with a huge orchestra, chorus and all the rest, and perhaps more Beethoven violence than any other of his violent works. (Beethoven's favorite mode of energy production is the instantaneous change from very soft to ultra-loud and vice-versa. Nothing in all music is more difficult to record.)

The Eroica, on the other hand, though it has its bad moments for any engineer, is on the whole a smoother piece of music. Recorded without the impediment of cluttery chorus, it can be given a more favorable mike treatment. Hence, without much doubt, the superiority of sound in this recording compared even with the all-instrumental first three movements of the Ninth—same conductor, same orchestra, probably the same recording equipment in the same hall. It's terrific.

(Other recent Walter Beethoven's were the First Symphony and the Triple Concerto for violin, cello and piano.)

Beethoven, Symphony #5.
Boston Symphony, Koussevitsky.
RCA Victor DM, WDM 1313 (4)

● While we're at it, here's still more Beethoven. This is a familiar version of the Fifth, both in many performances by the orchestra itself and in the old Koussevitsky recording (pre-NBC Symphony) made with the London Philharmonic (VM 245). Compared with the ultra-electric Toscanini version it is fusty, heavyweight—but that is not necessarily the comparison you will make. If you like your Beethoven fairly pompous, with a huge-orchestra sound, in a large hall, this is your version. It is an excellent, solid, concert-style performance—but no definitive masterpiece of interpretation. The recording is up to the best in RCA Victor's long series of Boston Symphony albums. Naturally, it's on 45 and 78, standard-length records, whereas the last Fifth reviewed here, that

from London ffrr with the Paris Conservatory under Schuricht, was on Long Playing at 33-1/3. Comparison is thus not easy, but musically speaking, the ffrr job is more intense, lighter in its "weight," faster in feeling (if not actual tempo), excellent as to general outlines, but sometimes a bit sloppy in detail. Try it if you want a "different" Fifth; otherwise the Boston version is what the doctor ordered—provided you have a 45 player. And so much for Beethoven.

Debussy, Suite from "Pelleas and Melisande." (arr. Leinsdorf)
The Cleveland Orchestra, Leinsdorf.
Columbia LP: ML 4090
78: MM 845 (3)

● It's strange that after the dozens of assorted suites from the Wagner operas, beginning 'way back with the celebrated Stokowski "Symphonic Syntheses," no one until now thought of synthesizing the "Tristan" of French opera. "Pelleas and Melisande," which has often been described as the greatest of Debussy's works, is virtually never heard except occasionally in what have been infrequent opera performances. (The opera has suddenly blossomed out with performances by New York's City Center opera group during the last year or so.) The idea was good, and Leinsdorf's treatment is excellent; three sections are included, with the briefest of pauses between, and each is a more or less continuous flow of music from a typical section of the opera, making for an almost symphonic three-movement pattern.

"Pelleas" is later, more acid, more concentrated Debussy than the familiar "Afternoon of a Faun," but not so advanced that it can't still rate as first class atmosphere music, Impressionist to the last note. It is, compared with Wagner, low in key, depending on subtleties and nuances rather than the Wagnerian torrent of sound; on first hearing it may seem rather neutral and colorless to you. But let it play three or four times—it makes first-rate background music—and it'll begin to catch.

Incidentally, this was one LP record I originally had consigned to the "buzzy distortion" category because of some loud passages in the third excerpt, near the inner groove. Now, with the GE "Type 3" stylus, it is perfectly OK, though I'd suggest that there is a bit of purely electrical distortion in those same loud passages. A good recording, technically, though not top rank.

Glazounoff, Violin Concerto in A minor, Opus 82
Nathan Milstein; RCA Victor Symphony, Steinberg.
RCA Victor DM, WDM 1315 (3)

● This should theoretically be one of those chestnutty violin concerto recordings put out as convenient and innocuous vehicles for virtuosi—and in a way it is that. But even so, it turns out to be a surprisingly mellifluous and lovely item in the actual playing. Not that the concerto is anything of great musical importance. But RCA Victor here has hit an ancient and well-known stride, in which Victor has been a specialist for years and years; from the first note of this recording we are openly and effectively treated to schmalz. The recording engineers know exactly what's needed and they give it—a soft, romantic acoustical texture, a sensuous violin tone, close up (but never

strident or metallic), a huge orchestra somewhere far off in the dim, rosy background, scarcely intruding at all on the soloist's domination of the mood. In any other concerto, especially one with real musical guts, this treatment is disastrous. Here it is luscious. That's the word for it.

Sibelius, Tapiola (tone poem).
Sir Thomas Beecham, Royal Philharmonic.
RCA Victor DM, WDM 1311 (2)

Haydn, Symphony # 73 "La Chasse."
Indianapolis Symphony, Sevitsky.
RCA Victor DM, WDM 1312 (3)

"Onward Christian Soldiers"
RCA Victor Chorale, Shaw. Carl Weinrich, organ.
RCA Victor DM, WDM 1314 (3)

• These three albums more or less set the tone of recent RCA Victor classical releases. The contrast with other large companies is quite astonishing, and one wonders whether RCA has decided to shift over largely to classical "pops" albums. Add to these the Glazounoff album (above) and a new Tchaikowsky Fourth Symphony, a new Beethoven Fifth—heroic warhorses but still war horses just the same—and the picture is for the moment completed.

"Tapiola" is one of those works on which, as of today, there is utter and complete disagreement. There are still those who assert that S. is one of the greatest of recent 20th century composers and that "Tapiola" is one of his finest works. There are plenty of others, and I'd say an increasing number, who find Sibelius the Prince of Dullness. For better or worse, my ear leads me in that direction. I concede a great skill and individuality of orchestration in this man's works. I allow a tremendously high score on the grounds of mood-creating, tone painting. But all of this is outside stuff. Music that *is* music should be foreground—not background. Not even background for daydreaming (in a concert hall seat)!

And so, to my ear, "Tapiola" is a gorgeously dun-colored description of vague Finnish forests of the North, an excellent piece to put on and not listen to. Don't be discouraged by this—my requirements aren't necessarily yours, and no one said anyone didn't have a moral right to enjoy mood music, as millions obviously do. I'm merely stating the "facts" as best I can. Sibelius has his place and a good one—but no one has as yet persuaded me that these tortuous and gloom-ridden pages are any sort of masterpiece of musical construction, except perhaps in the relatively outward aspect of theme transformation. Well . . . let's not involve the engineering world in this ancient and hoary controversy of the musical area! Suffice it to say that the Beecham interpretation will not be surpassed, that RCA has somehow managed to remove virtually all the higher tones from this English recording at some point in the processing—leaving it more dun-colored than ever, though with excellent acoustics as far as mike pickup and hall resonance are concerned.

As to the others, the Haydn Symphony is an interesting piece, played in a hard, efficient and unmusical manner, with fine recording; lots of highs (here, at least) and an excellent liveness. The "Christian Soldiers" album will elicit the scorn of the

For back issues of AUDIO ENGINEERING, see our listing on page 26.

highbrow musicians, but it definitely fills a great need, and I can find no reason to complain. These are standard, familiar hymns, the like of which are sung by the millions come Sunday all over the land, and sung in varyingly dreadful performances too. Shaw's professional group here shows our choirs what they could do if they just had a mind to. The performance is accurate, peppy, fast-paced, musical. Each verse has a different choral arrangement—giving choir-masters a survey, so to speak, of the various ways in which a given hymn tune could be treated by the choir to give variety in the repeats of the music, verse after verse. Better call this album to your own choirmaster's notice.

Pinza in Operatic Arias (Bellini, Rossini, Puccini, Verdi, Halevy).
Ezio Pinza, Metropolitan Opera Chorus and Orchestra.
Columbia LP: ML 2060

● The fabulous Pinza here takes time off from "South Pacific" (see Columbia LP ML 4180) to project a few conventional operatic arias, via the Met. Most interesting thing here is a new mike technique that puts the Pinza at a considerable distance—stage-distance—instead of the earlier Columbia method which had Pinza and others "tonsil-close" (as I once described it) with the orchestra in the liveness-background, giving a strange and not uninteresting distortion of perspective. But this is really better. More natural.

Note on LP

Columbia has now reissued so much of its past library of recordings that it no longer makes an attempt to count 'em, and doesn't bother to send out special LP announcements. But they still keep coming, and the latest batch includes monumental reissues of the huge Handel Concerti Grossi recording (on 4 large LP's, replacing three enormous heavyweight volumes of the old 78's) and the complete Brahms Requiem. There is considerable confusion now in placing all of these, for though some are obviously in the "reissue" category, Columbia—and others—tend now to bring out their standard and LP versions of a recording a month or so apart, sometimes with one ahead, sometimes another. This department therefore gives up trying to separate "reissues" from "new recordings" as a hopeless job. However, you are urged, if you are an LP collector, to keep regularly up to date on the continuing re-issue scene, since each recording that comes out on LP is a new factor, sometimes worse, sometimes better than its original 78 counterpart. I'll print an occasional round-up of unusually interesting items of reissue, to help.

Note that whereas LP reissues, both Columbia and elsewhere, are now almost un-numberable, the reissues on 45 from RCA and Capitol (the latter also on LP) are negligible in the classical field. So far I have noted roughly a dozen 45 reissues worth special notice—but then, that's according to my own taste, which is not monopolistic. Nevertheless, it's obvious that there is to be no immediate delving back into the huge RCA catalogue of available older recordings. And that is that.

SUBJECT INDEX

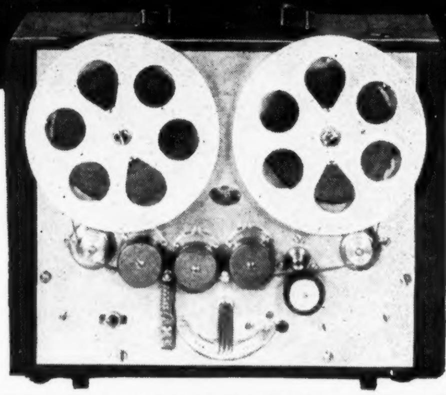
Audio Engineering—Vol. 33—1949

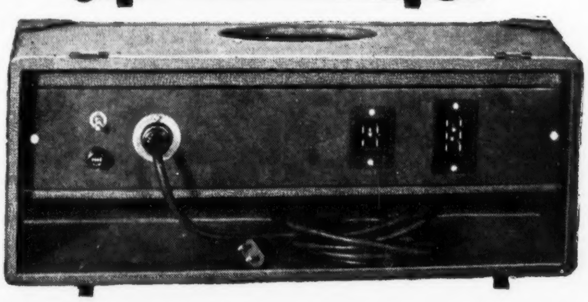
AUTHOR INDEX

ADVERTISING INDEX


CAST ALNICO V and VI THIN WALL RINGS
FOR MAGNETIC FOCUSING ASSEMBLIES
Quality and Quantity—NO PROBLEM!
In TELEVISION SETS, magnetic focusing eliminates blur; gives clear, sharp reception even during warm-up, or line voltage fluctuations; and the first focusing adjustment is the last. The thin ring-type permanent magnets of Alnico V and VI produced by Arnold for this use (several sizes are pictured here) are cast, not sintered, in order to save on first cost. It's a difficult job, but Arnold's advanced methods produce these rings in the desired quality and any quantity, without trouble. —No matter what the application, in any grade of Alnico or other materials, you can depend on Arnold Permanent Magnets. We'll welcome your inquiries.
THE ARNOLD ENGINEERING COMPANY
Subsidiary of
ALLEGHENY LUDLUM STEEL CORPORATION
147 East Ontario Street, Chicago 11, Illinois
Specialists and Leaders in the Design, Engineering and Manufacture of PERMANENT MAGNETS
AL
ARNOLD

NEW PRESTO
PORTABLE TAPE RECORDER





PRESTO'S PT-900 is the answer for delayed sports broadcasts - field recording—wherever there is a need for a portable recorder of complete broadcast quality. Look at these outstanding engineering features:

• Three separate heads for superior performance (and for monitoring direct from tape). One head each to erase, record and play back. • 3 microphone channels with master gain control in recording amplifier. • Large V.U. meter with illuminated dial to indicate recording level, playback output level, bias current and erase current, and level for telephone line. • 2-speed, single motor drive system. Toggle switch to change tape speeds from 7½" to 15" per second.

Don't choose your tape recorder until you see the *new* Presto Portable Tape Recorder. Write for complete details today.

PRESTO

RECORDING CORPORATION
Paramus, New Jersey
***Mailing Address:* P. O. Box 500, Hackensack, N. J.**
In Canada: WALTER P. DOWNS, Ltd., Dominion Sq. Bldg., Montreal

WORLD'S GREATEST MANUFACTURER OF INSTANTANEOUS SOUND RECORDING EQUIPMENT AND DISCS

FOR

SMALLER POWER COMPONENTS

High temperature (class H) insulation, and, in many instances, short life requirements, can effect considerable weight and size reduction where these are important. The curve at the left indicates anticipated life versus temperature rise, using Class "H" insulating materials. The curve at the right illustrates on one typical type the variation in weight with permissible continuous operating temperature.

TOROID DUST HIGH Q COILS

UTC type HQ (permalloy dust) coils have found wide application because of their high Q, stable inductance, and dependability. Four standardized groups of stock coils cover virtually any high Q coil application from 300 cycles to 300 Kc.

MAGNETIC AMPLIFIERS

Magnetic amplifiers are used extensively for both power control and phase control. The left curve shown is that of a sensitive saturable reactor structure controllable with powers below .5 milliwatt. The right curve is that of a moderate size power control reactor indicating power to the load with saturating DC.

AUDIO FILTERS

The curve illustrated shows a group of filters affording sixteen separate bands in the audio and supersonic region with 35 DB attenuation at the cross-over points. These have also been supplied spaced further apart (40 DB cross-over), with intermediate bands, permitting flat top band pass action for any selected range from 100 cycles to 200 KC.

May we design a unit for your application problem.